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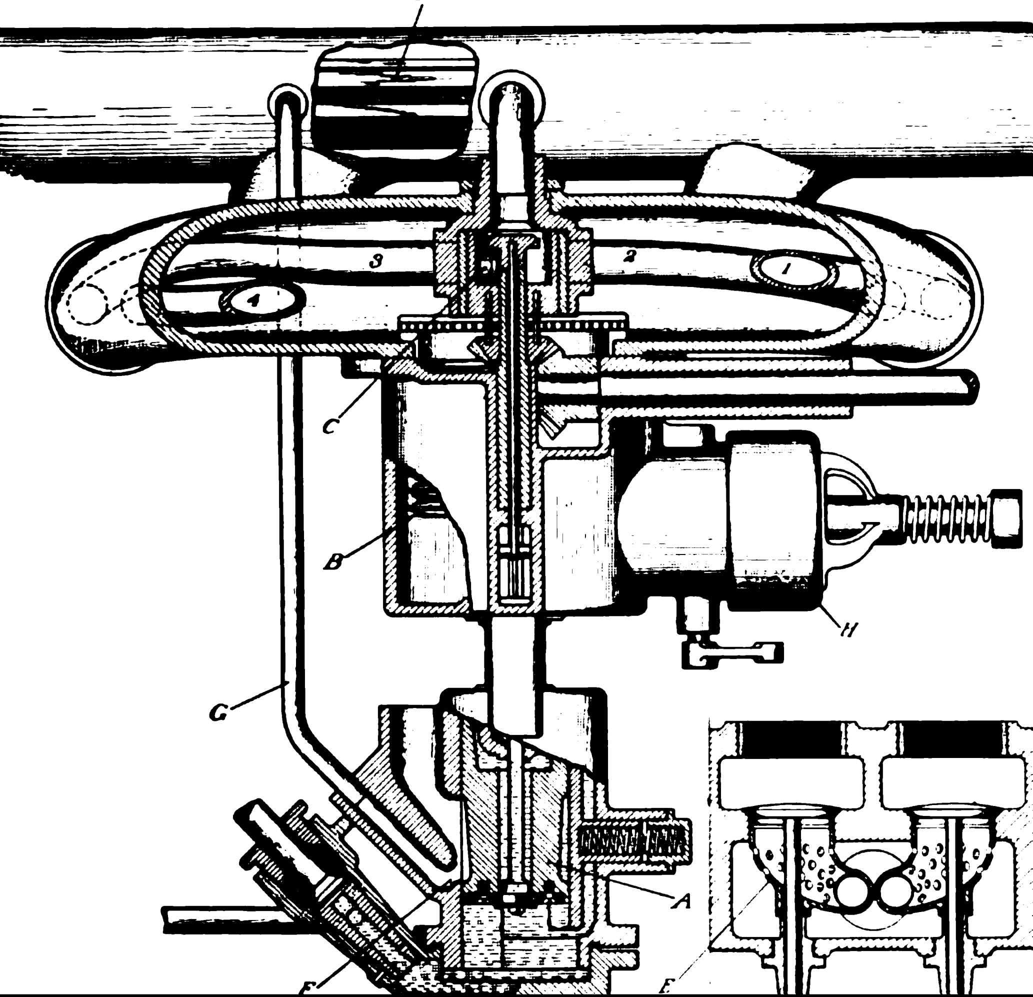

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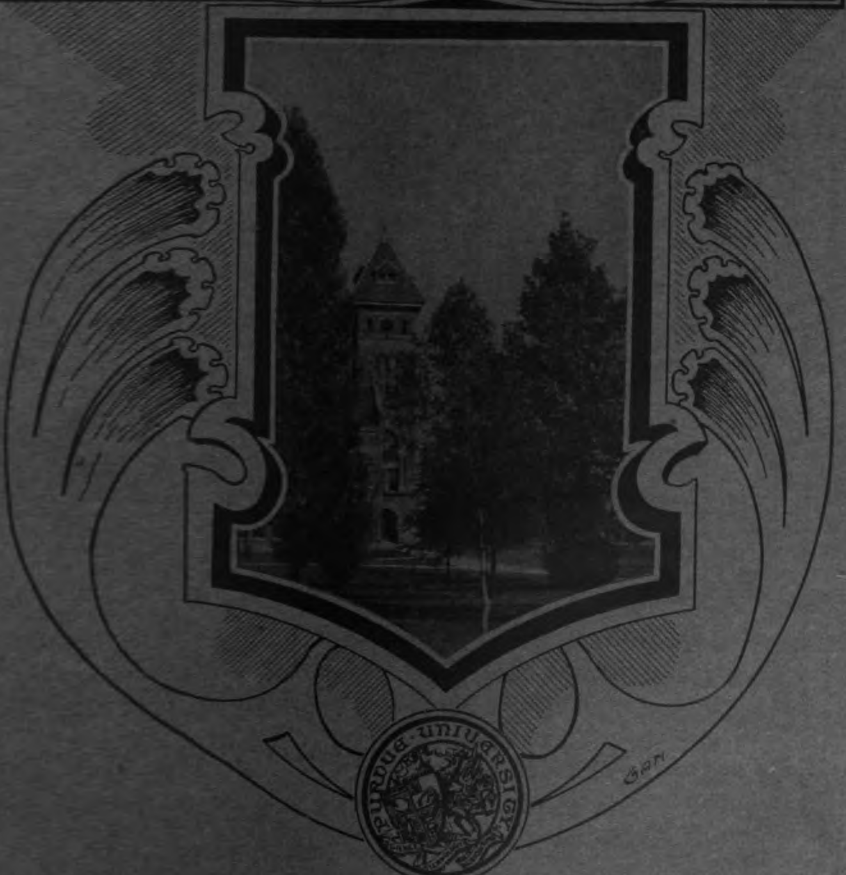

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PURDUE
ENGINEERING REVIEW

Vol. XIV, No. 7 **PURDUE UNIVERSITY** **1913 - 1914**

A KEROSENE CARBURETOR

C. E. Summers, '06

The rapid development of the motor industry has drawn heavily upon the supply of fuel adapted for use in motors as now constructed. The outlook for future application of portable power points toward even greater development. No other source of power known to engineering science seems likely to supplant the explosion type of motor in this field. In view of these facts, the scientific world, the manufacturers, and the public have been inquiring what fuel can be produced in such great abundance as to meet the increasing demand without reaching a prohibitive price. Much effort has been expended to find a new product which will be a cheap substitute for gasoline in the present type of motor, or to produce a motor or method of carburetting which will make the heavier petroleum products available as fuels. Alcohol, benzol, and other substitutes for gasoline have been tested, but owing to higher cost or limitations in production, give little promise of relieving the situation.

Kerosene presents the most likely solution to the problem. This is true because average crude oil contains approximately twice as much kerosene as gasoline, and while the demand for gasoline has increased many fold during the last decade, the demand for kerosene has normally decreased. Kerosene differs from gasoline principally in the physical properties of greater specific gravity and higher boiling point. Kerosene has approximately 10 per cent. more fuel value per gallon than gasoline, and is obtainable in most parts of the country at less than one-half the cost. Because of these natural advantages, the efforts of most experimenters have been directed toward devising means for making kerosene available as a fuel for internal combustion motors.

Manifolds and carburetors as now constructed are designed for fuel which, when sprayed into the air, immediately vaporizes and is carried directly with the air. This condition is not realized when kerosene is used, since its boiling point is from 300 to 500 degrees Fahrenheit. If sufficient heat is given to the mixture to hold the kerosene in a state of vapor, the entire charge is so expanded, due to the high temperature, that the horse power of the motor is seriously reduced. If we apply but little heat to the mixture, the fuel is only partially vaporized, the remainder creeps as a film on the walls of the manifold, feeds into the cylinders irregularly and divides between them unequally, resulting in little power, smoke, large fuel consumption, and generally poor results. It seems evident, therefore, that no device could be attached in place of the conventional gasoline carburetor which could so treat kerosene as to give perfect results if the charge must subsequently be elevated through a manifold and divided between the cylinders at random. A kerosene carburetor of necessity includes a kerosene manifold.

The device with which this paper deals has been designed with a view to eliminating the causes which have led to failure or meager success in the use of kerosene in the multi-cylinder throttling motor. Fig. 1 shows the device as applied to the average automobile motor. Its essential elements consist of the measuring member A, the regulator B, the distributor C, the vaporizer D, the atomizer E.

It is noted that the measuring cylinder A is rotated by gear connection with the motor. The cylinder is immersed in the fuel so the grooves in its surface fill with the liquid, and such portion of the contents of the groove as is above the lower edge of the port F discharges, due to gravity and suction, into the tube G which communicates with the vaporizer D. The distributor C rotates synchronously with the cam shaft and connects the vaporizer successively with each of the four tubes, 1, 2, 3, and 4, leading to the atomizer cones E placed beneath the intake valve of each of the four cylinders. The sequence of communication between the heater and each of the four distributing tubes is the same as the firing sequence of the cylinders. In this way the flow of vaporized or partially vaporized fuel is simultaneous with the indraught of air through the perforations of the atomizing cones E, insuring the positive introduction and thorough mixture of the fuel with the air in the cylinder.

The regulator B is the vital part of the mechanism. It consists of a sealed metallic diaphragm filled with air and adapted to axial expansion. The diaphragm is so located that it is subjected to the temperature and pressure conditions existing in the intake manifold and consequently in the cylinder during the intake stroke. The air sealed within the diaphragm exerts a pressure upon its yielding walls which, when the external pressure is lowered, causes the diaphragm to expand. An increase of temperature with constant external pressure also causes expansion. Thus the length of the diaphragm becomes an accurate index to the

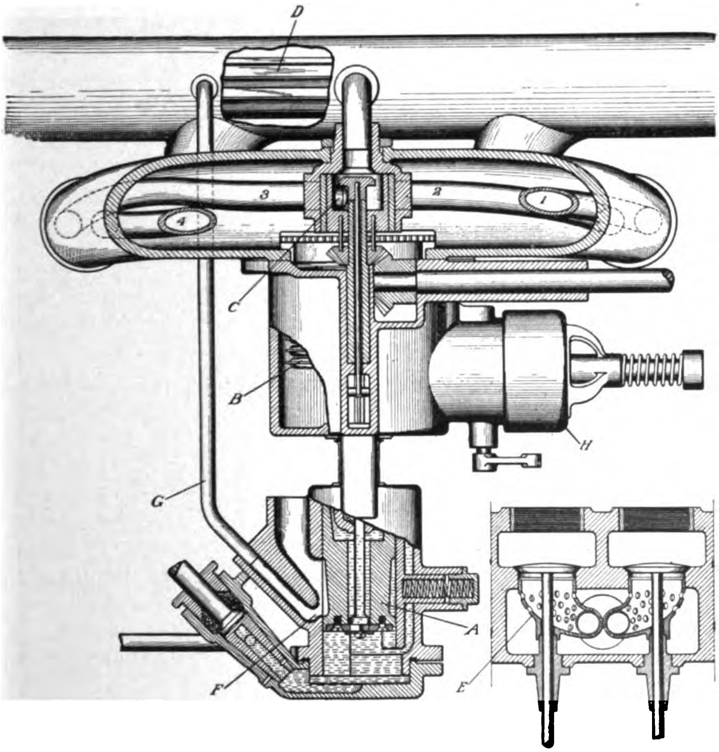


Fig. 1.

volume of any given weight of air, when subjected to temperature and pressure variations. The change in the length of the diaphragm for various pressures and temperatures is determined experimentally, and the volume of liquid fuel necessary to enrich the piston displacement volume of air under these same conditions of pressure and temperature is calculated or determined by experiment. Then by connecting the diaphragm with the feeding cylinder so the collapse of the diaphragm brings a greater length of the fuel slot into discharging relations with the port F, and by giving such form and variation to the depth of the slot that the volume of fuel above the discharging line at each vertical position corresponds exactly to the amount required to enrich the weight of air being taken by the cylinder, a balanced charge is obtained. It will be noted that this method of fuel feeding is independent of the volatility of the fuel. A slightly less volume of kerosene is required than of gasoline, but the greater viscosity of the former makes its discharge slightly less complete, so that this difference is compensated.

In Fig. 2, the curve A-A, co-ordinating external pressures and lengths of the diaphragm, is determined experimentally by varying the pressure surrounding the sealed diaphragm and noting the length. The curve B-B is also determined experimentally, and co-ordinates length of the diaphragm against internal pressure (gauge), and shows the internal-external pressure difference required to overcome the elastic resistance of the walls of the diaphragm for various degrees of expansion. By adding the ordinates of these two curves we obtain the hyperbolic curve C-C, whose equation has the form $X\,Y = C$. Solution of the curve locates the Y axis.

The fuel requirements of the charge at constant temperature vary directly with the absolute pressure, reaching zero at a degree of vacuum at which the clearance gases expand to fill the entire cylinder at the line D-D, Fig. 2. The slope of tangents drawn to the curve A-A indicates the rate of fuel requirement relative to the diaphragm variations. Thus, with the volume of the groove in the cylinder A equal to the volume of fuel required to enrich the piston displacement of air, the variations in the depth of the groove conform to the value of the tangent of the curve A-A for a pressure absolute and a diaphragm length which brings this particular point of the groove on a level with the

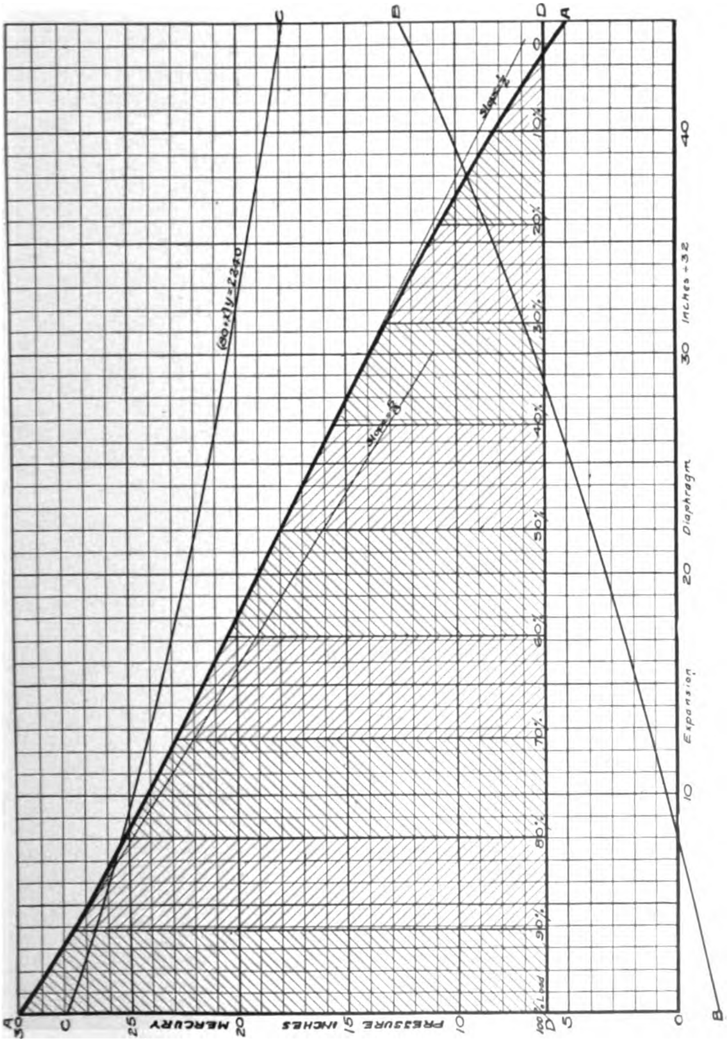

A
B
C
D
(80+x)y=2240
Slope=½
Slope=8
0
10%
20%
30%
40%
50%
60%
70%
80%
90%
100% Load
30
25
20
15
10
5
0
Pressure Inches Mercury
10
20
30
40
Diaphragm Expansion Inches ÷ 32

Fig. 2.

charging line. By this means, not only can a balanced proportion of air and fuel be maintained, but any variations in the proportion found desirable can be given. For instance, at full load of quantity of fuel can be fed giving maximum power, while at lighter loads the minimum amount of fuel is supplied, giving high efficiency and insuring clean spark plugs.

A few of the practical advantages of the carburetor are as follows:

1. A perfectly balanced mixture is obtained at all times, giving maximum efficiency.

2. The device is self-adjusting to all conditions of load, speed, temperature and barometric pressure, thus requiring no manual adjustment.

3. The fuel is introduced positively into each cylinder, and equally distributed between the cylinders.

4. The introduction of the fuel through a separate tube from the main air supply permits of any desired heat treatment without overheating the entire charge.

5. Mechanical control of the fuel supply makes it possible to feed a lean mixture at light loads, thus insuring clean spark plugs, and yet feed a mixture for maximum power at full load.

6. Because the device delivers the fuel directly to each cylinder, vaporized and in its right proportion, and regulates automatically for temperature, it is especially adapted to use low grade fuels.

7. The motor starts easily in cold weather, because the fuel is delivered directly to the cylinder, and a mixture of full richness is fed when the motor is cold.

In practical tests covering several months the device shows even greater economy than would be expected from theoretical considerations. An automobile which averages 12 miles per gallon of gasoline using regular carburetor equipment, makes 22 miles per gallon of kerosene when equipped with this carburetor. The secret of this economy lies in the thorough vaporization of the fuel and the introduction of the smallest amount which will give the desired result. The device has the advantage of using gasoline, kerosene, or any mixture of the two. The impossibility of overfeeding gives it a remarkable fuel economy whether using gasoline or kerosene.

UNUSUAL STRUCTURAL FEATURES OF THE FLETCHER SAVINGS AND TRUST BUILDING INDIANAPOLIS, INDIANA

Louis W. Bruck, '09

The Fletcher Savings and Trust Building is located at the corner of Market and Pennsylvania Streets, in the heart of the business and financial district of Indianapolis, equally distant from the Federal building, City Hall, County Court House, and State House, and within two squares of the four leading banks of the city. The building site on which it stands is valued at 480,000 dollars, the structure itself, exclusive of any interior fixtures, will cost about 875,000 dollars. The building lot measures 97 feet 6 inches by 120 feet, and the building will have a 20 foot basement, with 16 stories above, reaching 217 feet 6 inches above the street level. The Fletcher Savings and Trust Company will occupy the whole of the lower three floors, with exception of the store room space, with their banking room and offices. The remaining 13 floors will be leased for general office use.

The exterior of the building will be finished with white granite up to the fifth floor level, above which Indiana limestone is to be used. A very painstaking effort has been made to impress the observer that the building is a bank as well as an office building. To this end, a great deal of emphasis has been placed on the bank entrance on Market Street. The walls have been set back three feet or more in the three lower stories, and massive granite columns introduced, 35 feet high. These are well proportioned and serve in their arrangement to distinguish the banking rooms from the remainder of the building in a very pleasing way. The attainment of this object has at the same time introduced one of the principal structural difficulties, for the steel columns above must continue down inside these granite columns, thus unsupported in a length of 39 feet. The direct loads on these columns at this point total 762,000 lbs.; and to these must be added a wind moment of 509,000 ft. lbs. The section thus obtained becomes excessive, and other means must be resorted to rather than the addition of cover plates and angles to the existing section. This presents one of the unusual features of the construction, which will be described in detail.

The interior of the banking room itself, elaborate in all of its details, is responsible for other difficulties. Approximately $100,000 is to be expended in the finishing and decoration of this one immense room, which the trust company will occupy. Needless to add, the demands of the architects in designing so large and expensive a room were very exacting. Reference to the plan of the room will show how few are the columns and how symmetrically they have

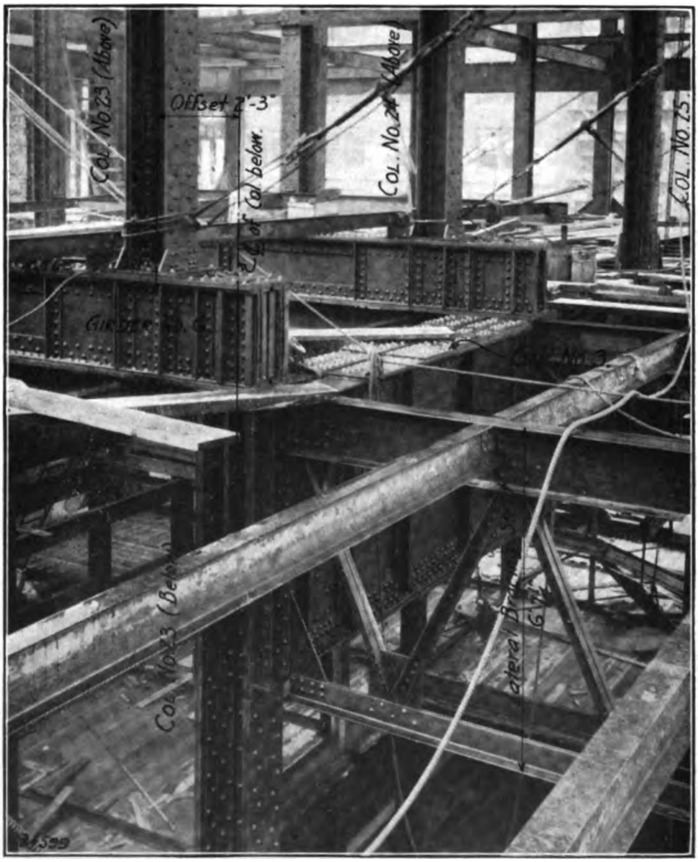


Fig. 1.

been placed to facilitate the working out of certain architectural schemes. In order that the elimination of columns above the banking room may be shown more plainly they have been dotted in on the plan of the room, five eliminated entirely, and 7 shifted in position. Ordinarily the shifting of a column in a skeleton frame building is not difficult, because room is easily obtained, by suspended ceilings or otherwise, and the construction easily taken care of. However the troubles were rather complex in this case. Little room was allowed for the necessary girders, and the construction for that reason was difficult.

Fig. 1, viewpoint of which is given on the plan of the banking room, shows one of the unusual cases of offsetting and elimination of the upper columns. The double six foot girder No. 3, carries columns No. 24 and 25, eliminating them below, while column No. 23, supporting girder No. 3 at the near end carries also the smaller girder, No. 6, the latter made necessary by the offsetting of column No. 23. The second column in the view, No. 24, is offset in a similar manner and its load is likewise transferred to the large girder by means of the smaller one. An unusually small amount of working space was available for the depth of girder No. 6. The vertical shear in the near end of this girder is about 640,000 lbs. and the available depth for the girder was 28 inches. The compactness of the metal is well shown in the view, as well as the close spacing of the rivets in both web and flange. A double I section is used and each of the two girder sections has four web plates, two inside and two outside of the flange angles.

It will be noticed in Fig. 1, that the end connection of the girder No. 3 is riveted. A glance will immediately suggest that it would have been much simpler to rest the girder on top of the column, rather than running the column up through the girder. Some very difficult riveting would have been avoided and the connection made much easier in the drafting room. One consideration, however, makes that scheme an impossibility, and that is the provision for girder No. 6, having a reaction at this end of 640,000 lbs. and coming above the top flange of the larger girder. To transfer this load down through the end of the girder below by means of milled stiffeners was found to be impossible because not enough metal could be assembled in the space available. The only other expedient was resorted to—that of running the lower column up through, and two inches above the top flange of the lower girder to form a bearing connection for the upper girder.

The other troublesome feature of the structural steel work was brought about by the granite columns on Market Street. Fig. 2 gives a detailed view of one of the connections along Market Street at the fourth floor, near and above the banking room entrance. These steel columns are entirely encased by the granite columns, which at the outset prevents any connection to them except from the room side. This gives a free length of about 39 feet for the steel columns which have a direct load of 762,000 lbs. to be combined with a wind moment of 509,000 ft. lbs. The outside dimensions of the columns were limited by the channeling of the granite to 16 inches. To find a section limited to these figures of sufficient strength would have resulted in a section both inefficient, and with excessive thicknesses of metal in both web and flange sides.

Another consideration in the same problem suggested a solution in itself. It was that of providing an efficient connection for the second floor girders at the second floor. These girders along the street, it will be remembered, carry a wall which was set back over three feet from the corresponding wall above. This brought them two feet or more from the columns to which they were to be framed. Because of the architectural features it was not permissible to introduce a girder for framing and even this method would not have given opportunity of transferring wind stresses to the columns at this floor. One means of accomplishing both these objects was to place an auxiliary column, or strut about two feet inside the main column to take these connections with the wind stresses at that level, and to secure the two columns together by means of tie plates along their full length. This method was adopted, and all wind stresses from the fourth floor down were transferred to these auxiliary columns. The main section then carried nothing in the 39 foot length but direct load, and the section for such a load was easily proportioned. The method employed of transferring the wind stresses at the fourth floor is well shown in Fig. 2. The usual wind-bracing-girder, as designed for all the upper floors, is carried along the entire elevation, and connected to the main column by means of a gusset plate connection. A second girder, or latticed bracing is framed between adjacent auxiliary columns, and these connected to the outer girder by horizontal angle bracing. The inner line of girders has no load but that of the transferred wind stresses. Unfortunately it cannot be explained in detail in this article how much this solution simplified the working out of the connections of the floor beams, etc., in the shop details.

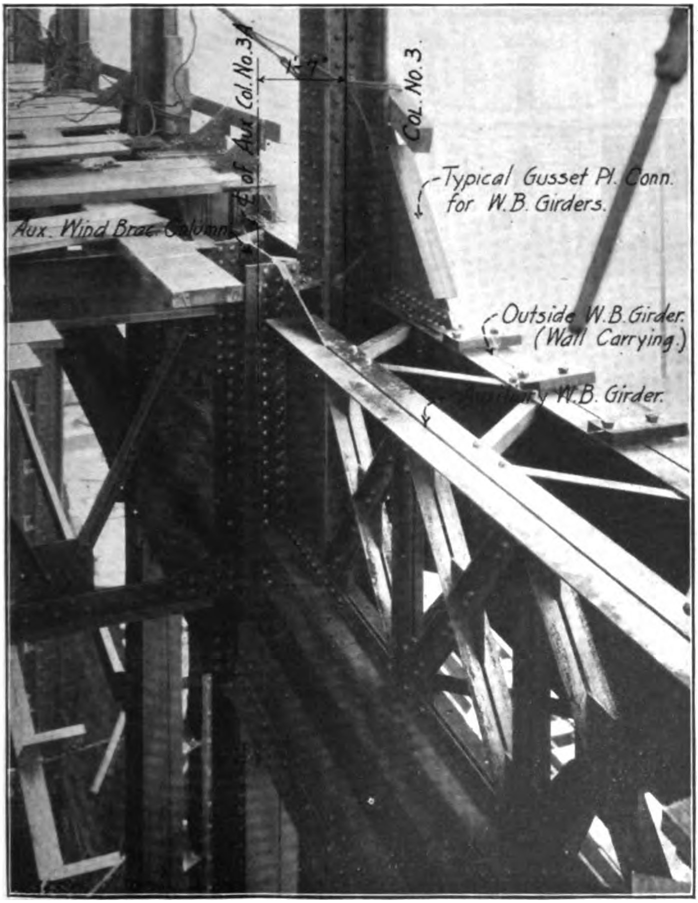


Fig. 2.

Another feature of the design which might prove of interest because its use is not yet common, is that of placing the splice in the outside columns in the middle of the story height—at or near the point of counter flexure. It eliminates the necessity of having very heavy splice plates designed to take the full amount of the wind moment in the column. An advantage of greater importance, however, in the shop is

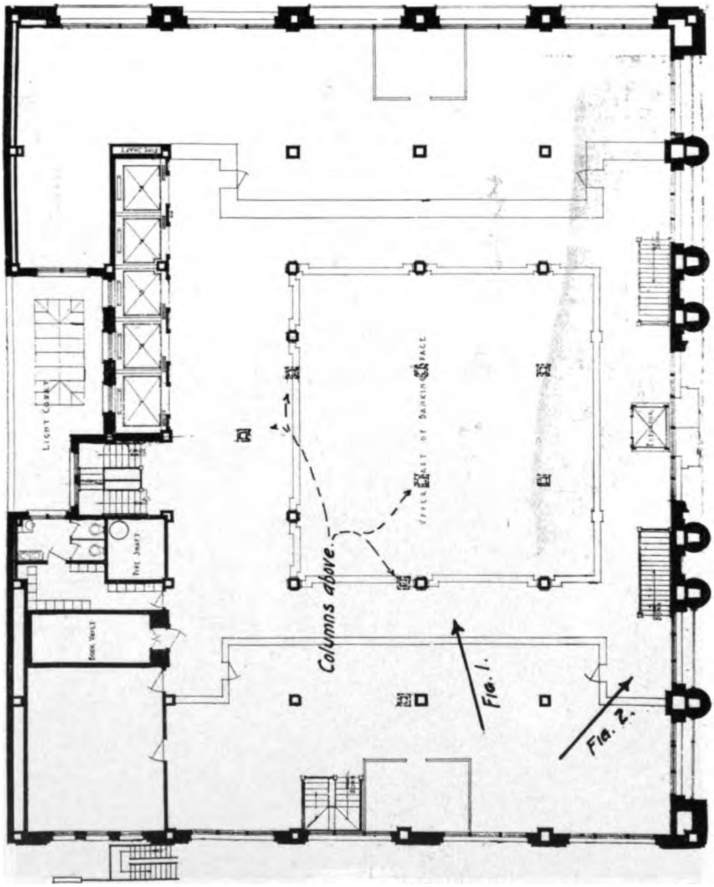


Fig. 3.

Plan of Banking Room.

that the location brings the splices clear of any gusset plate connection from either the floor above or below. In the ordinary design, with the splice 18 inches or two feet above the floor line, the gusset plate connections on the columns interfere with the column splice, and the two must be combined in the field connection—an awkward and costly detail, yet one which usually cannot be avoided.

Such in brief are some of the unusual features of the structural design of the building. They are not stupendous, nor entirely new and original in solution, but they are unusual, and as such they may prove of interest as illustrating some of the problems presented to the structural engineer, for which he must have ready solution. He must prove his value in solving such difficulties quickly, yet with the care and understanding of the methods and materials available that will render his scheme speedy of solution, economical in cost, and efficient in service.

THE LAW OF CONTRACTS

W. E. STARK, '14

All business is conducted through the medium of contracts, and whether it be the ordinary affairs of domestic life controlled by simple agreements or the erection of great public works controlled by carefully prepared contracts, the same law and the same principles apply. Without the medium of contracts business would be at a standstill. No man is able to take his place successfully in business without some knowledge of contract law. The writing of specifications should be considered along with the drawing of contracts. The contract is a proper task for the engineer, in that it must be drawn with reference to the specifications so that they may have the force and effect desired. If the specifications are drawn up by the engineer and the contract by the attorney, conflicts will arise frequently owing to each man's ignorance of what the other has in mind. Between the two evils, lack of legal knowledge and lack of technical knowledge, the former is often regarded as the less important and the contract is left to be drawn by the engineer. A contract prepared without regard for the legal principles is almost certain to lead to litigation either on account of a misunderstanding of the legal liabilities of the parties involved or of the failure to make the contract binding.

To assume the obligations arising from a contract, the law provides that the parties shall observe certain formalities and that their intentions shall be made known by certain acts that may be made a matter of record. There are four essential elements to a binding contract, namely, two parties with the ability to contract; a lawful consideration; a lawful subject matter; and a mutual understanding between the parties. If a contract does not contain all four of these principles, it is not binding and will not be upheld by any court.

The ability of a person to contract is not hard to determine. The only people who have any special privileges in regard to contracts are infants—infants being men under twenty-one, women under eighteen, drunkards, lunatics, and sailors. If a contract is injurious to the interests of an infant it is absolutely invalid, but if it operates for the infant's good it must be fulfilled or its equivalent given when the infant becomes of age. Sailors are especially protected by federal law. If a sailor incurs a debt of more than one dollar while he is on a voyage, it cannot be collected. In some courts, married women and bankrupts are free from obligations of contract.

A contract should always state clearly the residence of the parties as well as the place where the contract is drawn, since the laws effecting its execution may depend on these things to a large extent. For instance, a contract drawn in one state to be performed partly in that state and partly in another will be governed by the law of the state in which it was made, but a contract drawn in one state to be performed wholly within another state will come under the laws of the state in which it is performed. A contract cannot be enforced by any legal act unless some consideration is involved. The law does not permit the contracting of doing something for nothing. The consideration may not necessarily be money. It may be the surrender of a right or a privilege or the promise to do a certain thing. If the consideration of a contract is an act, the performing of that act cannot be taken as the consideration for a second contract. Taking a concrete case, if a workman is on a contract job which he quits for some reason before he has finished it, the promise to complete the job for a premium will not be upheld by the courts. The finishing of the job was the consideration for one contract and cannot be made the consideration for the second. There is a difference between a promise in consideration of some future act and a promise in consideration of a promise to perform some act in the future. If an owner says to a builder, "I will pay you ten thousand dollars to build me a house," and the builder answers, "All right," the promise to pay cannot necessarily be realized upon until the house is built. The owner may call the deal off before the house is completed and the builder may not be able to collect a cent. On the other hand, if the owner says, "I agree to pay to you ten thousand dollars if you agree to build me a house," the contract is perfectly valid since it is supported by a present consideration and not a future one.

Now comes the question of lawful subject matter. Contract law requires that the obligations assumed shall be lawful acts or undertakings within the written law of the land; that they shall be in harmony with the policy of the government and with good society; and that their execution shall be possible. The consideration must not be one prohibited by law. A contract must not tend to influence legislative bodies or public officers in the discharge of their duties and it must not have for its object the perversion of the courts or the obstruction of justice. Agreements to pay money to witnesses to remain out of court will not be enforced. Contracts made for the making of public utilities before the franchise is obtained, or contracts between builders to refrain from bidding against each other are illegal. A man cannot by contract forfeit certain rights and privileges which the law guarantees him. Contracts by which persons agree not to demand damages for injuries or negligence, such as the contracts of railroads, express, and telegraph companies, which seek to limit their responsibility in case of accidents, have frequently been set aside by the courts. The fact that a man riding on a free pass signs an agreement to release the carrier in case of injury to the passenger does not mean necessarily that he cannot collect damages in the event that he is injured in case of accident while a passenger. A case in point is that of the Indianapolis Traction and Terminal Company versus Isgrig, administratrix, in the Appellate Court. The court affirmed a former decision granted in favor of the defendant, stating, in its opinion, that a common carrier created as such by law, cannot contract against liability for negligence. This case arose on account of the death of a conductor in the employ of the company while riding on his transportation slip.

The last essential element of a binding contract is the mutual understanding between the parties as to the terms of the agreement. If it can be proved that a mutual understanding is lacking the mere signing of an agreement will not make it operative. For instance, an engineer draws up two contracts for the approval of his company. Both of them are signed and sealed and the company elects to deliver one of them, but by mistake delivers the other. If the company can prove that it did not intend to deliver the one that was sent, there is no contract. A contract subject to the conditions of some future agreement is held as not binding since the parties have not yet agreed as to the future conditions. It might seem from the consideration of these statements that any ingenious man could evade a contract, but such is not the case. The misunderstanding must be one that any man of ordinary sense would be liable to fall into, and could convince a jury that there was an actual misunderstanding.

It may seem that some points upon which a contract might depend would be decidedly hard to bring out to the court's satisfaction. To aid in the interpretation of contracts and to prevent fraud and perjury, statutes have been enacted which require that important contracts must be attended by certain ceremonies which may be cited in court as evidence. On account of the loss of certain evidence through the elapse of time other statutes have been passed whereby the period of liability of the parties is limited. Most states require that contracts relating to the transfer of lands and construction work must be made a matter of public record. It is required in some states that all contracts and specifications be recorded. The statute requiring that certain contracts be in writing in order to be enforced by court decisions, especially those involving more than fifty dollars in value, is known as the Statute of Frauds. This law usually contains a section governing sales, wherein it is stated that a contract for the sale of goods is not effective unless part of the goods has been delivered or a partial payment has been made. When the statute specifically states that the contract must be in writing, neither party has any recourse in court if this provision is not observed. The statute limiting the time during which a contract obligation operates is known as the Statute of Limitations. It is the purpose of the principles of this type of statute to compel the contracting parties to enforce their rights or abandon them in a reasonable time. Such provision gives security to business and makes unnecessary the indefinite retaining of receipts and like evidence. By its rulings, the plaintiff is denied the privilege of enforcing his former rights after the elapse of the prescribed number of years. However the action only is affected and not the defense. Thus a defendant may show that a contract was procured by fraud even though the statutory limit has passed.

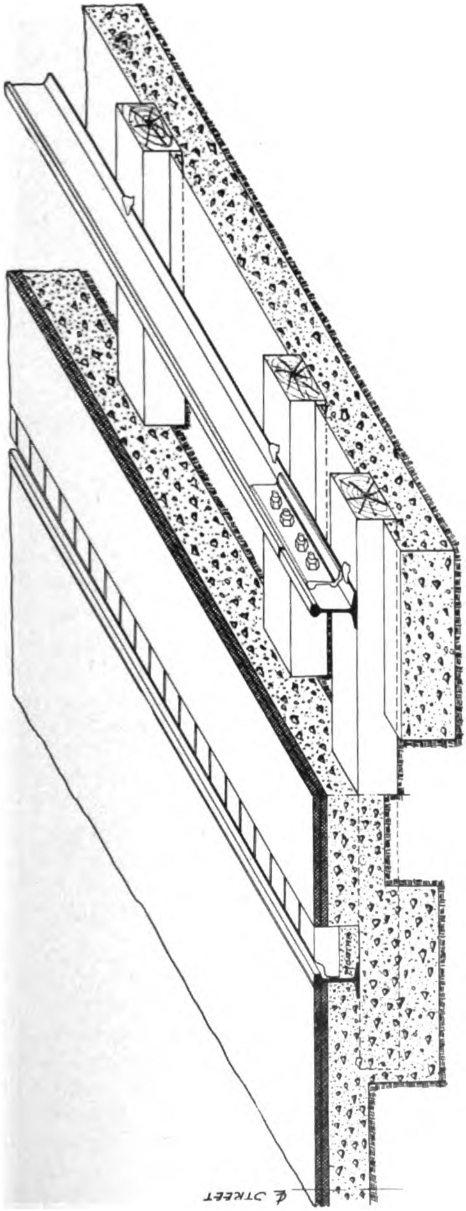
It should be kept in mind that in drawing up a contract very close attention should be paid to the essential elements. When the contract is completed it should be reviewed carefully to see that it does contain these features of a binding agreement, and that it is within the statutes limiting the law of contracts. The preparation of a contract is not a thing to be done hastily and the spending of a few hours of time may mean the saving of many dollars.

TRACK RECONSTRUCTION

J. R. McKAY, '11

During the summer of 1905 there were constructed several miles of street railway track of the beam type construction in Fort Wayne. A concrete beam six inches deep runs the entire length of each rail. On the assumption that the beam would be strong enough to carry the track vertically, ties were spaced every five or six feet apart except at joints where two ties were spaced very close to each other. It seems that the tie was counted upon to prevent the spreading of rails and not to distribute the load to any great extent. Reference to Fig. 1 which is an isometric drawing of one track on a street where there is double tracking, will show the most salient features of this type of construction. All the track so constructed in this city has proved a failure. At the present time there is left to be reconstructed only a few miles of both single and double track of this type. Most of this is in such a condition that it will have to be replaced within the next year. It is upon the reconstruction of over 4,000 feet of double track of this type that this article shall be concerned.

Before discussing the reconstruction of the beam type of track it might be interesting to note some of the features concerning its failure. The most glaring fact was that for almost its entire length the track was lower than the adjoining pavement by several inches. In some instances the track was as much as four or five inches below the pavement on either side. Only recently on some of the track which is still in and is to be replaced as soon as spring opens, it was necessary to shim the rail up seven inches in order to permit cars to run over the spot. This fact in itself shows that the beam was very inferior to most ordinary types of construction and that there was not sufficient width in the beam to properly sustain the load and transmit it to the subsurface whose bearing power is poor. At joints, where there was considerable vertical motion, the beams would break, and during wet weather, under the continuous rise and fall of the track as cars passed over these points, the subsoil would work its way to the surface through the beam and pavement. When the concrete beams were removed it was



CONCRETE BEAM CONSTRUCTION

FIGURE 1

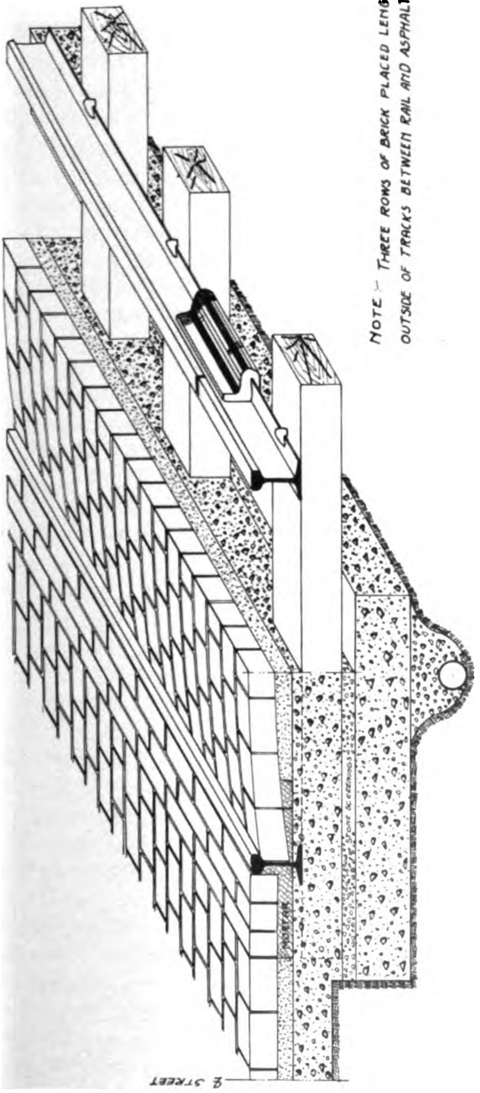
found that in many cases they were broken between the wide spaced ties.

To overcome the various bad features of the beam type and to provide a roadbed which will stand interurban and heavy city traffic, a standard type of construction as shown in Fig. 2 has been adopted.

The stability, permanence, and maintenance of any street pavement depend upon its foundation. If the foundation weakens in any way, the surface will soon settle unequally. If the street be one in which street railway cars are run this settling soon manifests itself in the breaking of the bond between the pavement and track construction. However, surface failure may be due to poor materials and workmanship independently of a good foundation. The essentials necessary for the construction of a solid unyielding foundation are a firm subsoil and proper drainage. The nature of the subsoil will to a large extent determine the character of the construction to be used.

The drainage of the track in a paved street, as that of a steam railroad, is one of the most important items in the economical maintenance. Under the increased loading, the rail tends to deflect and consequently the bond breaks and permits water to enter the foundation, which if not properly drained will at once displace the subsoil and break down the entire construction. The drainage is cared for by subdrainage and surface drainage. The subsoil is drained by a line of four inch vitrified ring tile placed in the center line of the track. The tile is surrounded by crushed stone to permit the water to collect and enter the open joints of the tile without carrying soil with it. The more solid and compact the subsurface is made the better the drainage will be. Hence before the under drainage is placed, the soil is thoroughly rolled with an eight ton roller. This rolling also furnishes a firm foundation for the concrete slab.

The surface drainage is cared for by drips which are connected with the city sewerage system by eight inch vitrified pipe lines. The drips are placed at breaks in grades on downward slopes and where there is a slope of such length as to warrant the reducing of distances. The small four inch drain lines are connected to the outlets of the drips. Thus the water which may get below the track construction and that which collects along the rails in the flange-way spaces is adequately taken care of.



NOTE:- THREE ROWS OF BRICK PLACED LENGTHWISE LIE ON OUTSIDE OF TRACKS BETWEEN RAIL AND ASPHALT PAVEMENT.

CONCRETE SLAB CONSTRUCTION

FIGURE 2

To carry a heavy interurban car without crushing and to prevent joints from loosening, a foundation of concrete of varying thickness and seven feet six inches wide is used. This foundation is of a 1:3:5 mix and in the work of the past summer it was eight inches thick. In order that there may be sufficient elasticity to permit cars to ride easily and not jar, a cushion of two inches of crushed stone is placed on the concrete foundation. In places where it is desired that there be great rigidity, the surface is obtained by blocking up the track and then pouring a wet, rich grout beneath the ties. The blocking is subsequently removed.

White oak ties 6 x 8 in. by 7 ft. spaced two feet on centers are employed in the standard of construction now used. The 7 in. 91 lb. T-rail, 60 feet long, is heavier and stiffer than that formerly used and therefore will retain a permanent alignment and grade. Such a rail also reduces vibrations and deflections to a minimum and prevents the rapid deterioration that would result in the use of a lighter section. Its height permits the placing of a brick under the ball and permits of a better appearing pavement. A 60 foot rail while not so easily handled as the shorter ones reduces the number of joints 50 per cent. and gives a smoother track. All joints are cast welded at an additional cost of more than 250 per cent. above the cost of ordinary splices. A brick surface between tracks and 1 foot outside of the outer rails is used in every class of pavement. The chief reason for this is that when it becomes necessary to open the track for any purpose the brick can be removed easily, and replaced with less cost and damage to the appearance of the street than is the case with other types of pavement.

The track constructed upon plans of the more recent standard construction is located on a street which is the artery of traffic for practically the whole rural district southwest of the city. During the improvement of this street it was necessary to keep at least one side open to traffic, and one track had to be available for city and interurban car operation. Because of these facts it was necessary to carry the work on with the greatest dispatch.

The work of excavating was done with a Thew shovel having a capacity of ⅝ of a yard. With a work car and gondola at hand this shovel operated by a competent engineer was able, in spite of constant interruptions, to remove on the average 200 cubic yards of material per day. Not only did the shovel tear out all the old concrete beams but the ties as well. More work was done at a very much lower cost than would have been possible by hand. The cost of removing this material by hand would have exceeded a dollar a yard as the beams were of such dimensions that they could not have been handled without first breaking them into suitable sizes. The shovel did its work so well that only two men were needed to follow up and do the fine grading. Perhaps the most valuable feature of the shovels work was the time saved.

As soon as the shovel had finished enough of the excavation to insure that the concrete mixer would not catch up, the work of placing the foundation was commenced. The mixer used was of one bag capacity and was run by a motor, which took current directly from the trolley wire. This machine with a gang of 18 men and a foreman was able to lay nearly 500 feet of foundation per day. After the concrete had aged sufficiently (one week or 10 days), the track laying gang started the placing of ties and rails. After placing 500 feet of track it was surfaced. The grade could not be obtained in every case from the adjoining pavement as it was no longer on a uniform slope. It was necessary to take levels over a distance of several hundred feet and then fit a grade to the conditions differing as little as possible from the original grade.

Immediately after the track had been surfaced and lined, the mixer which had already reached the far end of the track was removed to the starting end and the work of concreting the ties in place and putting down the pavement foundation was commenced. This work progressed almost as rapidly as did the work of laying the slab foundation so that it was not long before the paving gang was able to start its work.

Before the paving was begun the joints were cast welded. A gang of 12 men with a foreman were able to cast about 36 joints per day. The welder used consisted of a cupola mounted on wheels with a steam engine attached for creating the necessary power for blast. All joints were ground off smooth by an electric grinder made by the Kerwin Machine Company. This machine is automatic and can grind 20 to 25 joints per day depending upon the hardness of the rails.

After the entire west track had been completed, work was started on the east track and carried out along the same lines. The organization on this work was excellent and because of the efficient management both tracks were completed and opened to traffic within a little over three and one-half months, in spite of the fact that the work was hampered by bad weather. The track and pavement are the equal of any in the city and will without doubt stand up under a good many years of hard wear.

SUMMARY OF ACTUAL COSTS

Excavation (including all materials and labor) per cu. yd.	$0.39
Track Work (materials and labor for removing and relaying) per ft. single track	1.96
Special Work (one left hand turnout, total length 84 ft. with labor for installing) per ft. of track turnout	6.54
Cast Welding and Grinding per Joint	5.08
Drainage per foot of single track	0.16
Concrete per cubic yard	3.68
Paving (materials and labor for laying surface only)	1.09
General Expenses (Engineering, Watchmen, etc., per foot of track	0.10
Overhead (changing trolley, etc.) per foot of single track	0.009
Average cost of entire work per foot of single track	5.15
Average estimated cost per foot of single track	5.62
Net saving per foot of single track	0.47

AN AMERICAN STUDENT'S IMPRESSION OF A GERMAN ENGINEERING SCHOOL

G. A. WAINWRIGHT, '11

"Purdue University? There is no such a thing. I am quite familiar with the geography of America and there is no state named Purdue." This was my own rather discouraging reception at a German technical school and it almost led me to believe that registrar's clerks are of a cold and suspicious nature the world over.

I found it quite impossible to pass the outer guard with my Purdue credentials, but on presentation of my high school diploma—a very pretentious and elaborate document—I was immediately treated with the deference which should be due the proprietor of such a paper. My Purdue diploma might be all right—he still had his doubts that I was working a confidence game—but unless I could prove that I had attended a high school, I was not of the elect. His misunderstanding of course arose because of the fact that their *Hochschule* is in reality the *high* school of the country, and since the entrance requirements for foreigners require the attendance at some high school he was not aware that in our use of the term it is a misnomer. This is merely an example of the red tape which all German public institutions permit to hamper them. The American student's first impression is that there is an inexcusable lack of system to the whole organization. This idea gradually gives way to a doubt as to whether or not there is really too much system; so much that the place is involved and entangled in it until the whole effect is that of hopelessly intertwined red tape. When one considers the appalling fact that the process of matriculation, which we require about twenty minutes to complete, there consumes five days, it is easy to believe that at least something of office efficiency has been sacrificed to departmental formulae.

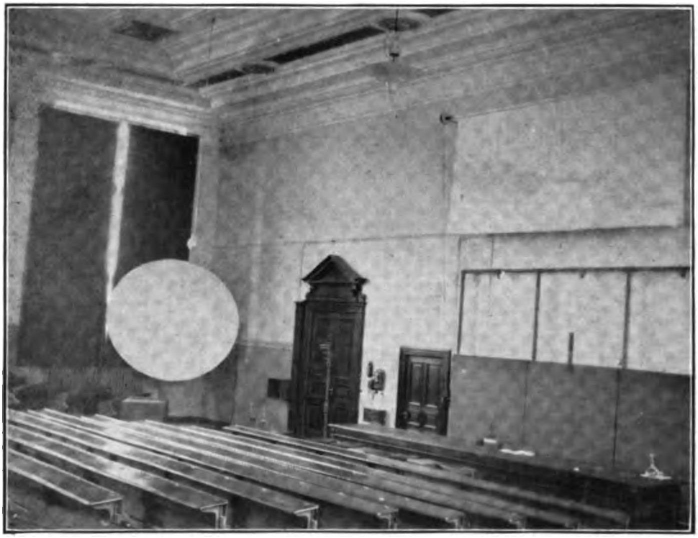
My references here will be largely to the *Königliche Technische Hochschule zu Berlin* as I am more familiar with the details of it than with any other. First your credentials must be filed and receipted for in the office of the secretary. At the same time he takes from you a deposition concerning your personal and family history that is nothing if not complete. No little detail can escape this inquisitive question blank which covers everything from the social rank of your grandparents to the number of murderers in your immediate family. There intervenes then about two weeks while a no less personage than the *Minister der Geistlichen Angelegenheiten* considers your credentials. The first real important step in matriculation then occurs when you have your prescribed personal meeting with the rector. He is an awe-inspiring potentate who may be addressed only as *Euer Magnifizence,* and on the occasion of this first meeting he grasps each new student by one hand and thrusts into the other a bundle of entrance papers and a small library of rules and regulations; after which he gives a short address of welcome strangely reminiscent of what many American college presidents say on similar occasions. The student then lists the subjects he chooses to take on a paper furnished for the purpose and turns it in to the registrar for him to calculate the fees. Each course is paid for individually and the instructor usually shares in the money which is paid by his classes. A very wise provision is made in the collection of a trifle for the academic sick fund which insures the student free medical attention and very cheap medicines and nursing.

After only a short delay—two or three days—the paper containing the student's planned work is returned to him, and a day or so later an opportunity given to pay the fees. The paper need be signed by the head of the general science department and each professor under whom work has been elected and the student is ready to start. The choice of subjects is left absolutely to one's own sweet will. The catalogue even apologizes for grouping them under department headings, saying that in so doing it is not attempting to influence or restrict the student's choice of subjects, but begs to recommend what is a very good course. To one who has ever attended a school where the catalogue, with full knowledge and consent of the faculty, plainly intimates that you "may take the following named subjects in the following named order, or you may seek your education elsewhere," this becomes a real lark. To be sure, in order to qualify for an examination a certain list of things must have been taken, but if the student prefers to take the senior year first or chooses to spread the four years' work out over eight, no great obstacle will be placed in his way.

Attendance is also purely elective. If you attend classes, no one will know it, nor will they if you do not. There are no roll calls. In the beginning the rector advises the student to attend classes "as often as convenient," but there is no attendance committee to encourage the adoption of this advice. Men occasionally attend only the two times a semester which are necessary for the signing of their *Anmeldebogen* and trust to home study and diligent cramming to pass the examinations. In technical schools there are two of these examinations: a preliminary after two years and a final at the end of four, which when passed leads to the degree of *Diplom-Ingenieur*. These are most thorough and grilling affairs and it is safe to say that without real knowledge of the subjects they are impossible. They are both written and oral and the final thesis or *Arbeit* must be an enormous affair and represent practically a year's hard work. The oral quiz, though held in the morning, must be attended in full evening clothes by both students and professors. They regard this the most important moment in a man's life and they do not propose to have the dignity of the occasion marred by anything as frivolous as a red necktie.

The most lavish thing about a German school is the vacations. The school even starts with one! For three weeks after the announced opening of school, not a class is held. The German people present a strange paradox in their observance of rules. It is well known how implicitly they obey their signs of *"verboten"* and how countless absurd regulations are adhered to to the letter, simply because they are regulations, and yet in other cases hard and fast laws are consistently ignored for years without any apparent reason. Their Christmas vacation, nominally of two weeks becomes three in practice and a like period at Easter stretches into a month. Frequently other single days and week ends are interspersed throughout the year and make quite a large total: Thanksgiving, Ascension Day, Whitsuntide, the Kaiser's birthday, etc. At the end of the school year the students commence going home two weeks to a month before the real closing date and the professor himself calmly closes up shop and quits when the last one has left.

The actual work done is almost exclusively by lecture and in laboratories. A view is shown of a large lecture room in *Königliche Technische Hochschule zu Berlin*. The large circle to the left is a picture screen. The projection apparatus is directly in front of it and hence may be operated by the lecturer without an assistant. The black-board is in three sections, each of which may be raised independently by hydraulic pressure to permit those in the rear to see the entire board. In some cases the colloquium and seminar correspond in a fashion to our recitations, but these occur in only a few subjects. It is in the personnel of the lecturers that the great and incalculable superiority of the German technical school over the American is manifested. These men are the acknowledged superiors in every line of work in the Empire. When a man has done so much and accomplished so many things that the nation is at a loss how further to reward him, he is presented with the title of "Professor" and he becomes a man apart, for this is an honor respected and revered as no other in civil life. I have in mind a man who rose from the ranks as a shop foreman, through factory superintendencies and managerships until his fame was nation-wide and he was regarded in the mechanical world as a marvel of skill and inventiveness, and when through his wonderful organizing ability he had attained to a place in industry second almost to none, he



A Lecture Room.

received a royal command from the Kaiser to go to Charlottenburg and teach school. It speaks much for the efficacy and good standing of a school system when a man like the betitled *Herr Geheimer Oberregierungsrat Professor Doctor-Ingenieur honoris causa* A. Martens, a man whose connection with the steel industry will never be forgotten, still cares to ally himself with the instructional staff of a technical academy.

Germany takes her schools seriously. The student is in an exalted class in their society, and in a land where caste is a so vital consideration, his enviable position lends a tone to the whole educational scheme that is an enormous factor in making the schools what they are. He is the idol of the people in his gay-colored cap and his ribbons, and his huge scars excite admiration wherever he goes. He may visit the royal theaters at a fraction of the admission price and the royal museums free of charge. He even carries a card which makes him exempt from arrest, but he in turn in the full consciousness of *noblesse oblige* does not abuse this concession. (Let us shudder to think what would happen to some of the landmarks of Lafayette a few hours after some such cards were issued at Purdue.)

I have heard so many times the query, "Is it any value to an engineering student to study in Germany? Are there not more and better schools in America?" Let me say most emphatically that there is value, and great value in it. We have long conceded that we are a nation of engineers and that most of the work of importance that has been done in mechanical and civil lines has been done here. Blinded by our own glory, we have scorned the Germans as a nation of school teachers and scientists, and have failed to note that in their slow and painstaking path through the complicated ways of theory, they have come upon countless practical discoveries, and just as surely as they are becoming the admitted leaders of the world in commerce, so surely will they be able to give the United States a furious struggle to maintain her world supremacy in manufacture. They have practiced scientific management under other names for years and with that sharp faculty for assimilation which characterizes them they have absorbed all that is being done elsewhere and the result is one may look in vain for more modern and efficient shops than are found in Germany. The value of their schools lies primarily in the caliber of the men associated with them and the limitless opportunity for individual research in well equipped laboratories with the counsel of these same highly competent men always at hand. The secondary value and one by no means to be overlooked is the opportunities they offer of permitting a man to get an entirely different angle on affairs in general and to learn how other people think things out.

Their instructional methods are painstaking and accurate. The lectures read to the student are largely the result of the personal investigation of the lecturer. He takes nothing for granted and quotes other authorities whose work he has not personally verified only under protest. The work is inclined to be very theoretical and for this reason it would be of little value for one not a graduate of engineering to study there. One must know the fundamentals and be able to select for himself the valuable from the "of scientific interest only" or the work would be a maze of hopelessly useless matter which is in no wise simplified by the strange surroundings and stranger tongue. To illustrate, I recall a very distinguished lecturer's exposition of the so-called diamond point lathe tool. He set the point of the tool at the origin of 3-axial coordinates; developed each surface on the various planes of reference by descriptive geometry; and finally evolved equations for all the surfaces and lines bounding the tool. While this makes a very interesting two hour discourse, it might be a little vague to an American sophomore how it applied to machine shop practice. They give almost no shop work but in lectures detail every possible operation so fully that a man of any practical experience at all can follow them closely. Students who take examinations are required to produce evidence of a year's work in some shop along the line of their course.

The laboratory facilities are bestowed with a lavish hand in most of the schools. The *Königliche Technische Hochschule* in Charlottenburg has an engineering laboratory that cost more than two million dollars. The opportunity for individual research is such that the American student will find he can not duplicate in his own country. Limitless time is at his disposal and if his work is meritorious, almost any equipment he suggests will be obtained for him.

The undergraduate laboratories are very unlike ours. The rules, for instance, say that "the student is earnestly requested to hand in his report on experiments performed, for his own good." I do not recall that this form of obtaining reports is used at Purdue University. The reports themselves are purchasable in printed form and only the actual data and calculated results are necessary to complete them. In the laboratory, there are servants who start the engines, fire the boilers, open hot indicator cocks and clean the machinery after tests. The student is rather above menial labor. It is also quite right and proper for some one to relieve any suffering fellow student while he goes over to the bar in the main building for some beer or coffee. It is interesting to note that the engineering laboratory is treated purely as an aid to design rather than as a training school for operation of power equipment. For example, when we examine an engine for most efficient cut-off, they would probably experiment on various shapes of D-valves.

Inspection trips are frequent and very well conducted. They are made up only from the hearers of the particular lectures which they are to supplement and are hence very small parties. The factories inspected feel so signally honored by the visit of the students that they spare no pains to show their appreciation. Excellent meals and unlimited beer are always served to the students at these plants and addresses of welcome and many little attentions are fairly showered on them. These opportunities to see up-to-the-minute manufacturing and systems for promoting factory efficiency which would most certainly not be available to an American in any other capacity than as a student are in themselves well worth the trip over there.

The German students are companionable fellows and really little different from us if we disregard the superficialities. In general they are four or five years older than men in the corresponding school years in the United States, but this applies in all professions. With the German proneness to enjoy life a little as he goes along and not rush into it and have it all over at once, very few professional men complete their education and become self-supporting before they are thirty. This added age and the natural temperament causes them to assume a dignity quite foreign to the American student. There is no noisy relaxation between classes and jokes like campus tickets and ohm-sifter requisitions are quite unknown. They take their places quietly at lectures and sit respectfully throughout them, scuffing their feet perhaps if the professor does not speak loudly enough, but never throwing chalk or playing catch with erasers when his back is turned. They read daily and religiously the notices that are posted on the black bulletin board and never is there a pencil scrawl on the margin of an official notice "letters poor," "do over," although they do occasionally make a respectful annotation when the notices carelessly refer to the student body as *die Studenten* instead of *die Herren Studenten.*

School athletics are unknown—possibly due to some difficulty they might have making something rhyme with *Königliche Technische Hochschule* in a yell—and beer drinking and fencing are about the only indoor sports that appeal to them. These are not as exaggerated as is often represented, for it is drilled into the *Fuchs* by his older "brothers" from his first day in school that he must never become intoxicated under any circumstances.

Many of their customs are amusing and interesting in the extreme. Their whole attitude toward the work is different from ours. If a lecturer is late, they do not cut the class promptly at five minutes after the hour, but sit around and wait very impatiently for him to arrive. If he is quite late he is reprimanded on his appearance by a loud scuffing of the feet on the floor. Approbation is expressed by stamping and one soon acquires wonderful aptness in this footwork and it is never long until the most verdant freshman is able to scuff promptly when an assistant drops an eraser or stamp furiously when the lecturer tells some particularly good professorial joke. (Professorial jokes are perennials in Germany as in many other countries and spring up annually in the same place) The seats fill up from the front, not from the rear, and many go to class half an hour early in order to secure good places. The professor enters after all are seated—never before—and greets the students with a formal bow, which they often return by rising in their places. Important school functions, such as installing a new rector, are attended by representatives of the numerous clubs and organizations in the most resplendent of uniforms and paraphernalia. The costumes present a beautiful mass of gorgeous colors and the soldierly bearing of the men make these gatherings a truly imposing sight.

"Is the German which one learns in two years in college sufficient to meet the needs of an American student?" It is not. But added to this, two months of diligent effort in the midst of German speaking people will enable the student to understand practically everything. The cost of a year in

Germany of course depends upon the man. The living is about as expensive as it is here, especially in the larger cities. The tales one so often hears about the ridiculously low cost of living are myths or else have their foundation in the past. A thousand dollars should cover the expense of one year bountifully; fifteen hundred, two years—for experience is a great economizer.

The man who can avail himself of a year's study in Germany and does not is committing a grave crime against himself. I need not touch on the cultural advantages of contact with this the most artistic and philosophical minded people in the world, nor the unexcelled opportunity to hear better music, see better art and attend better drama than is offered in any other land, but purely from the standpoint of the young engineer who is anxious to place his time and capital where it will bring him the greatest return. I am convinced that he will find no better investment than a few semesters in a German technical school.

ELECTRICAL HEATING UNITS AND HEAT INSULATING MATERIALS

M. E. LOUTH, '13

At the present time, there are four ways of changing electrical energy into heat: first, by the Joulean effect; second, by the electric arc; third, by the electric spark; and fourth, by electrolysis. In small electrical heating devices the Joulean effect is used. Since this effect depends directly upon the electrical resistance of the circuit, the question of electrical heating is diverted immediately to finding an electrical conductor which has a high resistance, and which shall together with this property have a reasonable manufacturing cost and good lasting qualities. Such a conductor has been found in a nickel-chromium alloy which is manufactured under various names, though the fundamental chemical formulae and qualities vary only slightly.

The question of unit construction now has to be considered. Will convection or conduction be better is the question which every heating engineer has to answer when designing a new device. A very common type of convection unit is found in the street car heater of today. A helical coil of wire, wound either on an insulator or suspended in air, is allowed to come in contact with cold air. A convection of heat follows, carrying the heat to the parts of the car desired.

The conduction type of unit is well illustrated in the electric flat iron unit. The fundamental construction consists in winding an insulator, such as mica, with a flat resistance wire, the unit being insulated on each side by mica, and then clamped securely against the metal part, which acts as the heat conductor. The larger part of the heating devices on the market at this time are constructed in this manner.

The entire field of electrical heating elements designed with round resistance wire is covered in hot air heaters, electric grills, horizontal toasters, and immersion water heaters. The unit is wound on a lathe or turning device. A slight pull on the unit spreads the coils and eliminates danger of short circuiting any section. The resistance wire may be carried directly to the terminal plugs, but it is more advisable to end the heating unit on one of the supports and run a low resistance wire, such as copper or nickel, from the end of the unit to the plug. This method eliminates a conduction of the heat to the plug, which will in turn decrease the chance of plug failure. The construction of units of this kind is very simple and leaves only the one problem for the designing engineer in determining what shall be used to support the resistance wire. Obviously, it must possess three qualities. First, it must be a non-conductor of electricity; second, it must be able to withstand a temperature of 700 to 800 degrees Fahrenheit; and third, it must possess enough mechanical strength to eliminate danger of breakage. The problem has been partially solved by the use of asbestos board, which, however, is not completely satisfactory on account of its mechanical properties. This material is best known as "Tegit."

Passing now to the more common flat wire unit, the problem of electrical insulation is still the main one. Trouble arises from the fact that all electrical insulators are unfortunately good heat insulators. If this were not the case, the flat wire could be wrapped upon a thin sheet of insulation with the same material on each side, and then clamped securely to the plate to be heated. Since this ideal electric insulator allows the heat to pass through directly to the plate, the wire and the plate will be at practically the same temperature. That would mean the end of the engineer's trouble. Burn outs and punctures through the insulation would be a thing of the past, for these are due to the extremely high temperatures at which it is necessary to maintain the wire in order to obtain the necessary amount of heat at the point of utilization. Since this ideal has not been reached, we naturally turn to that material which approaches these ideal requirements. The field narrows down to the two general classes—a fire proof combination in which the wire may be imbedded, or mica, on which the wire may be wound.

In using the imbedded system, the material must be at least 0.015 inches thick. This means that a large per cent of the heat is lost in being forced through to the heating plate, and that the efficiency is correspondingly low. In this type of unit, the air does not come in contact with the wire, which construction eliminates any danger of oxidation. This is, however, of secondary importance, since the nickel-chromium alloys oxidize only to a very small extent.

This leads us to the consideration of the mica wound unit. A notched piece, or arbor upon which the wire is wound, is placed between two pieces of mica and clamped to a heating plate. Mica can be used as thin as 0.005 of an inch, and will conduct the heat fully as well as a fire proof clay or varnish. Not only does the mica wound unit possess this added quality, but it is less difficult to construct, and if a burn out should occur, the renewal is but a few minutes' work. Mica, however, is very expensive, especially in large pieces. The growing demand for this type of unit has lead to the manufacture of "Micabond," which is scrap mica, held together by a cement. The factor of safety demands that it be used not less than 0.010 of an inch thick. The cement, or binder, burns out as soon as heat is applied, but since the pieces are clamped between plates, no damage results. The binder used in Micabond has a detrimental effect on resistance wire, since a chromium oxide forms on the outside of the wire, when burned at a high temperature. For this reason, pure mica should be used in all places where the cost over Micabond is not prohibitive. Most types of heating devices may be designed by the methods which have been indicated. Heating pads are an exception to the rule. It may be necessary to have a unit which may be bent or rolled into any shape without short circuiting or harming it in any way. To meet this demand, a resistance wire wound with an asbestos cord is used. The wire is bent back and forth, and is stitched to the sides of the pad to hold it in place. The efficiency of the pad is very low. This, however, is not made a point in the design of the pad, since the wattage is extremely low—the average pad runs about fifty watts.

In small electrical apparatus, such as irons, toasters, hot plates, and air heaters, it is not practical to attempt to prevent loss of heat by using a heat insulating packing. If we should take heating units, such as have been described, and place them in or around an oven, we would have a workable electric stove. The efficiency would be very low, and the cost of cooking, when compared to the cost when coal, wood, or oil is used, would be prohibitive. An electric stove, unless built on a fireless cooker principle, will be a failure commercially. In designing a fireless cooker, two questions have to be settled. First, what material shall be used as the heat insulator, and second, how thick shall the wall of insulation be made.

To solve the first problem, apparatus consisting of two sheet iron boxes with one inch space between the inner and outer box was constructed. The tops of the boxes were covered by a thick sheet of asbestos board to prevent a loss of heat upward. Four thermometers were used, two being placed on opposite walls of the inner box, and two on the outside of the outer box. The average of each pair was used as the true reading. The material to be tested was packed between the two boxes and covered over with the asbestos sheet. The source of

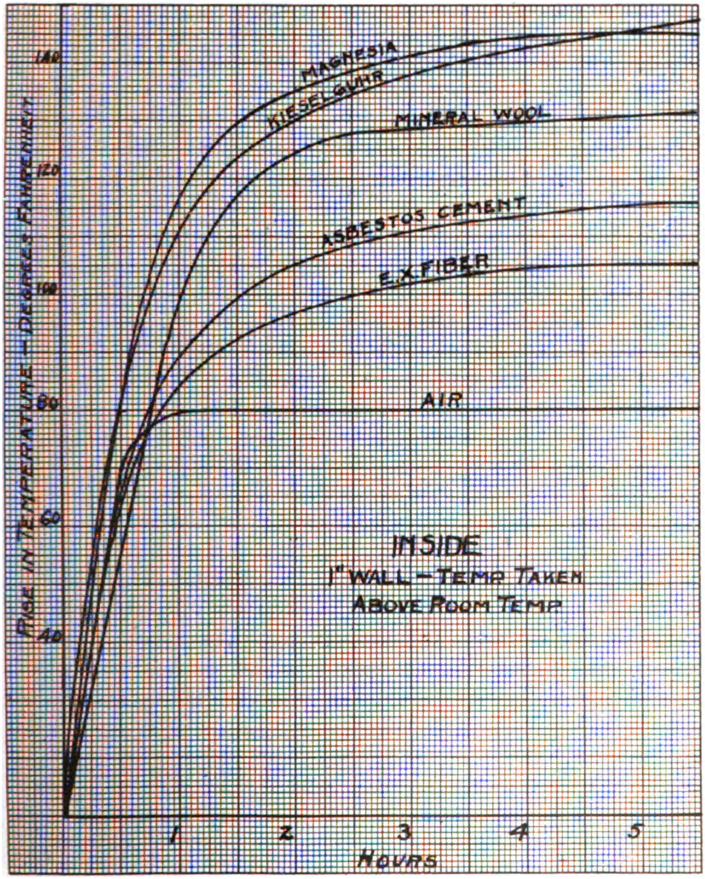


Fig. 1.

heat placed as nearly as possible in the center of the inner box. A sixty watt lamp at a constant voltage was used to give the constant heat required. Every precaution was taken to keep the test room at a constant temperature, and to keep all drafts away from the outside thermometers. All kinds of materials that might in any way be used for installation were tested in this manner. The tests would not, of course, show the efficiency of any one insulator, but would give a comparison of the different efficiencies.

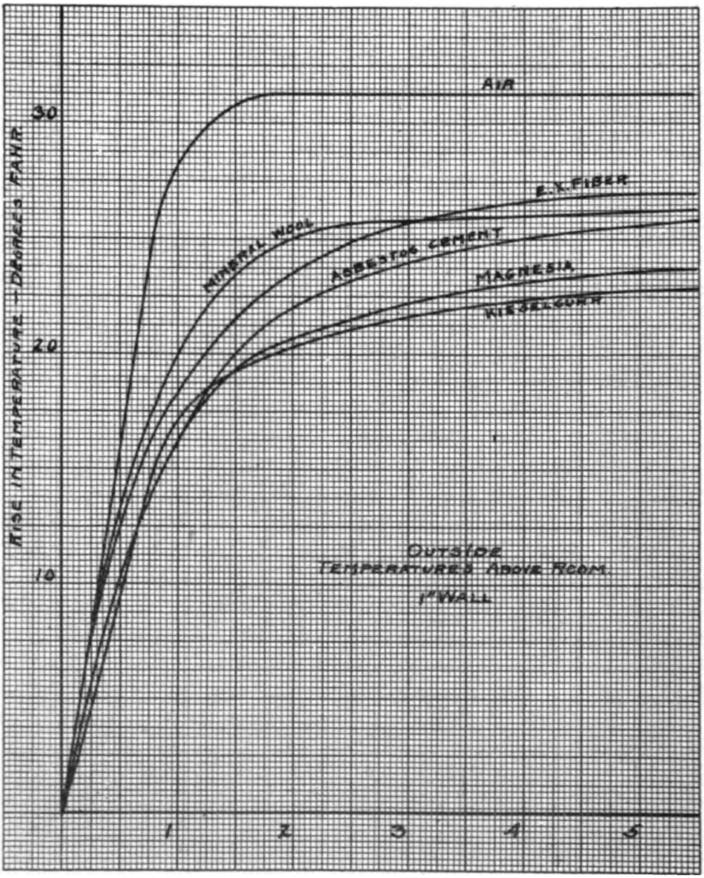


Fig. 2.

Three sets of curves shown in Figs. 1, 2, and 3, were plotted for the best insulators. The curves for air are also included to give a standard for comparison purposes. Fig. 1 shows curves with the temperature of the inside box plotted against the duration of time in hours that the test was run. The temperature plotted in all curves is about that of the room. Fig. 2 is a group of similar curves, with the ordinates showing the increases in temperature of the outside box, which depends directly upon the amount of heat that leaks through the insulation. Fig. 3 is a combination of the curves shown in Figs. 1 and 2, with the ordinates subtracted. The new ordinate represents the amount of heat

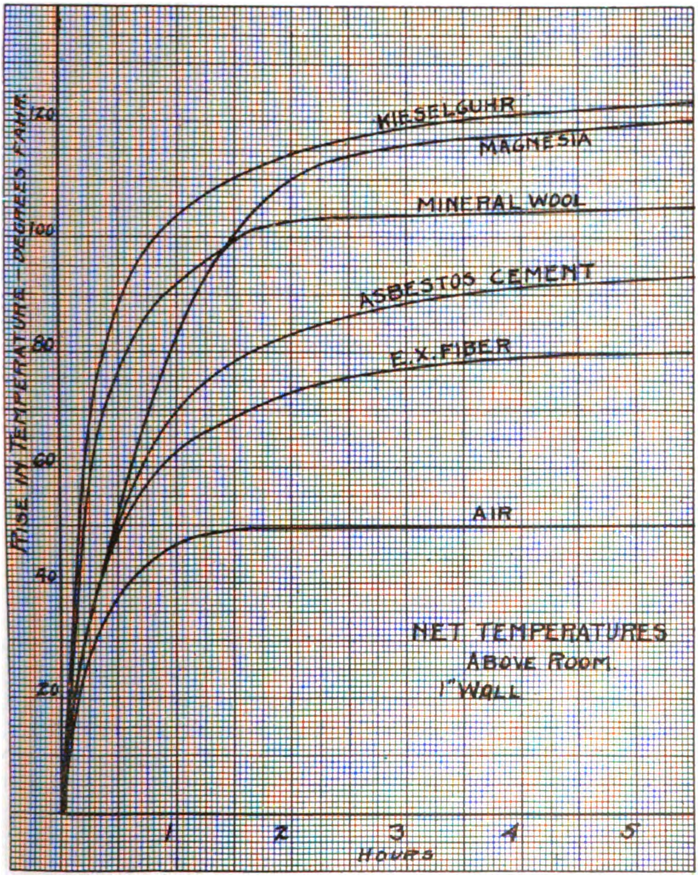


Fig. 3.

which the insulator has retained, and therefore, will give comparative results of the tests of the different insulators.

It is interesting to note in curves how quickly the air insulation reaches its equal radiation point. That is, after an hour and a half the amount of radiation just equalizes the amount of heat generated by the lamp. From that time, the curves continue in straight lines parallel to the time axis. It is also interesting to note how closely the curves for magnesia and kieselguhr follow each other. The magnesia used was of the common powdered variety and is familiar to every one. Kieselguhr, which in English means infusorial earth, is, as the name implies, a fire proof material. Its general appearance is very similar to that of magnesia. It is a dull white, and feels very much like a poor grade of baking flour.

Mineral wool is a tough fibrous material, resembling to a large extent rough wool. It has been the standard heat insulator for fireless cookers for years. E. X. fiber and asbestos cement are both compounds of long fiber asbestos. Both are fireproof.

Fig. 3, which gives the net results of the tests, shows that mineral wool, magnesia, and kieselguhr are the best insulators. Magnesia may be eliminated at once, since its cost is greater than that of kieselguhr and its advantages are not greater. This narrows the field to mineral wool and kieselguhr. Mineral wool has one distinct advantage over kieselguhr. It can be packed around an oven without making the containing box absolutely tight. Mineral wool, due to its fibrous make-up, does not have a tendency to leak through every crack. Kieselguhr will sift through every seam and crevice, and when it is used, all cracks and seams must be closed with stove putty or sodium silicate. Kieselguhr being light and cheap is considered to be the proper insulator for fireless cooker work. The thickness of wall used depends upon the amount of heat that the designer wishes to retain. The thicker the insulation, the smaller the amount of heat that is lost, but the greater the cost of insulation. The happy medium for good fireless cooker work, is between two and one-half inches and three inches. Above three inches, the added cost of insulation overbalances the added efficiency. As an example of the insulating properties of kieselguhr, an oven was heated to 380° F. and at the end of three hours, the oven thermometer recorded 362°, which means an efficiency of approximately 95 per cent. for the three hours' test.

COMMERCIAL ELECTRICITY

I. M. Kirlin, '13

Ten years ago the commercial department of the average central station received little consideration by the directors of the public service companies. New business was handled in the simplest way by inexperienced men with no technical knowledge of what they were selling and what it would be used for. While the business of the central station was taking care of itself, great effort was exerted toward increasing the efficiency of operation of the station, both by the manufacturer and station operator. Rapid developments in highly efficient generating and distributing equipment in the last few years served to arouse the dormant central station business.

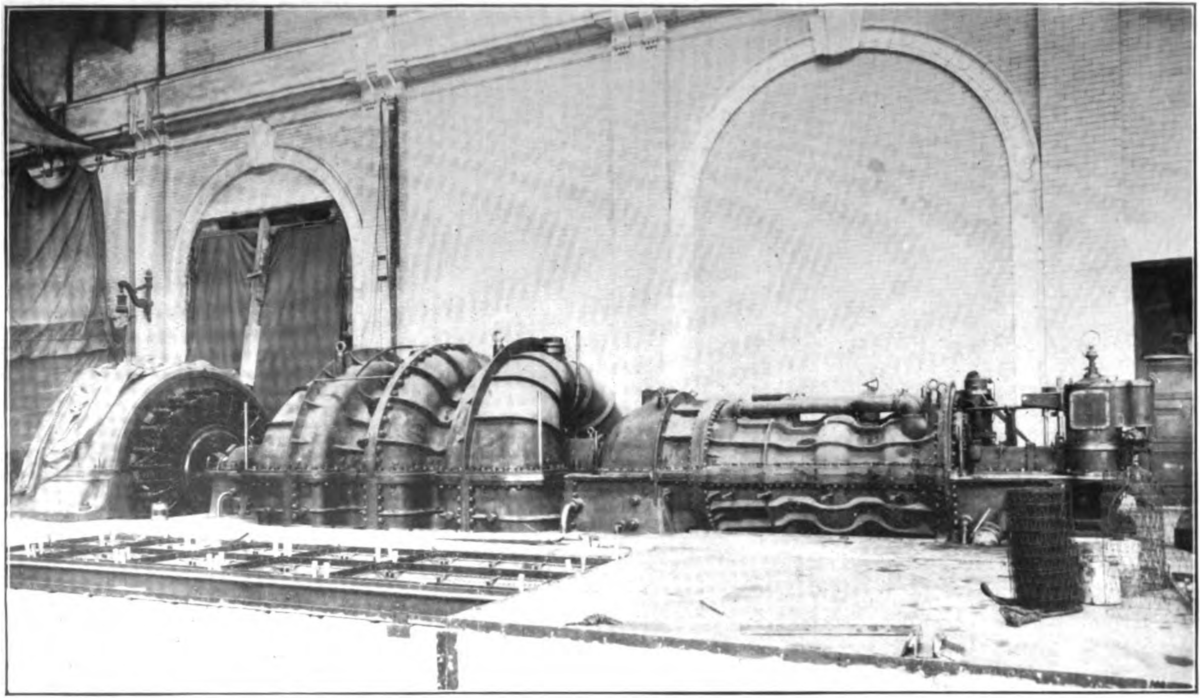
The first promoter to seriously consider the commercial side of the central station business was Mr. Samuel Insull, president of the Commonwealth Edison Co.—the largest central station company in the world—and allied companies capitalized at more than 570 million dollars. The commercial efforts of the Commonwealth Edison and allied companies have resulted in much greater use of household and industrial electrical appliances, a rapid increase in the industrial power load, and increased residential business on existing distribution lines.

The recent inauguration of Public Service Commissions by several states has led to considerable discussion among central station directors. The general opinion of promoters is that these commissions will work to the advantage of both the public service companies and the public served. Some such system was advocated by Mr. Insull twenty-five years ago.

The development of highly efficient turbo-generators, transforming apparatus, and distribution of systems has had so great an effect on the central station business that a system of merchandising electricity has resulted. Generating units of 25 and 30,000 K. V. A. have replaced smaller and less efficient units. Highly efficient transformers and transmission line constructions are serving to stimulate the growth of the centralized generating stations with general transmission to the distributing points or sub-stations. In the rural districts especially, is this latter system rapidly replacing the local generating station. All business of the company is governed by the central office of the system, the operation of the various stations or sub-stations being governed by the "System Operator." From his office all instructions to the local superintendents and the various departments are sent out over private telephone systems. The station, operating transmission lines, often secures a considerable power load by connecting with mines and pumping stations. The transmission line is sometimes tapped where the connected load warrants, to furnish power to farms. Each tap on a high tension line weakens the system, and where continuous service is of great importance taps for small loads are avoided. A duplicate line is frequently run to important rural installations to avoid any interruption of service.

The Commonwealth Edison Company maintains several large installations of storage batteries floating on the line to assure continuity of service, which is being recognized more and more as an essential in securing business for the central station. If all of the generating stations in Chicago went out of service at one time, service would be maintained by reserve storage battery capacity alone for a period of 30 minutes.

The effect of the introduction of tungsten lamps upon the public service company has been a subject for considerable discussion in central station circles. The objection was raised that the higher efficient lamp would reduce the revenue to the Company. Data collected by the National Electric Light Association, however, proves the contrary. Instead of the consumers' bills decreasing, the amount of light used increased to such an extent that the bills were practically the same as before; the illumination greatly improved; and complaints were fewer. Since this investigation, there has been put on the market the latest development in illuminants, the Nitrogen Vapor Lamp, with an efficiency of one-half watt per candle. That this lamp will meet with general approval by public service companies is little doubted, since the report of the investigation on the effect of tungsten lamps. The tungsten lamp enables the central station to compete favorably with gas as to cost, and the nitrogen lamp is expected to deal the gas arc its death blow for commercial lighting.



New Parsons, 25,000 k. v. a. horizontal type unit made in England being installed in Fisk Street Station. The overall length is 54 feet. All auxiliary apparatus is placed beneath it, and is motor driven.

The most important factors to be considered by the commercial department of the service company are the load factor and the diversity factor. The load factor is of prime importance and is defined as the ratio of the average load to maximum load.*

The load factor of the Commonwealth Edison Company is .46. The importance of a high load factor is evident when its effect on the cost of energy is considered. For example, the cost per unit of energy sold may be apportioned as follows—in large stations overhead charges equal 55 per cent and operating charges 45 per cent; in small stations the overhead costs and operating costs per unit of energy sold are nearly equal. Assume a station to have a load factor of .20, which is not uncommon in an undeveloped territory. The cost per unit of energy sold will be taken as 10 cents; one-half of this cost will be charged against overhead expenses including interest on capital invested, depreciation, taxes, etc. The other half or five cents will be the operating cost including cost of fuel, labor, etc., and will be independent of the amount of power sold. If the load factor is increased to .40 without increasing the maximum or peak load on the station, the primary of overhead portion of the cost per unit of the energy will be half as much as in the first case, since the output of the station will have doubled. Assuming the operating cost to remain at five cents per unit of energy, the total unit cost of energy has decreased to seven and a half cents. Thus, not only has the cost of energy to the service company been reduced, but the amount of energy sold has doubled.

The load factor depends largely upon the diversity factor. The ratio of the sum of the maxima of the subdivisions of any part of the system to the coincident maximum demand observed at the point of supply is called the diversity factor of that part of the system. Thus if the sum of the maxima on a group of customers' meters is 60 K. W. and the coincident maximum at the transformer serving them is 20 K. W., the diversity factor between consumers would be 60/20 or 3. The average diversity factor for residence lighting in Chicago is 3.35; for commercial lighting, 1.46; for general power, 1.3. The diversity between transformers on the same feeder is 1.4. At the sub-stations the diversity between feeders averages 1.15. Where there is about 25 per cent. of the light and power load of the city which has a 7:30 p. m. maximum, as in Chicago, the diversity between sub-stations is 1.1. The total diversity of the system is the continued product of the diversity factor between consumers, transformers, feeders and sub-stations. The total diversity factor for the Chicago system for all classes of service, except railway load, is at the present time 2.64. The load factor of all classes of consumers in Chicago is approximately .23, and, due to the diversity from consumer to generating station, the load factor of the system is increased to .46.

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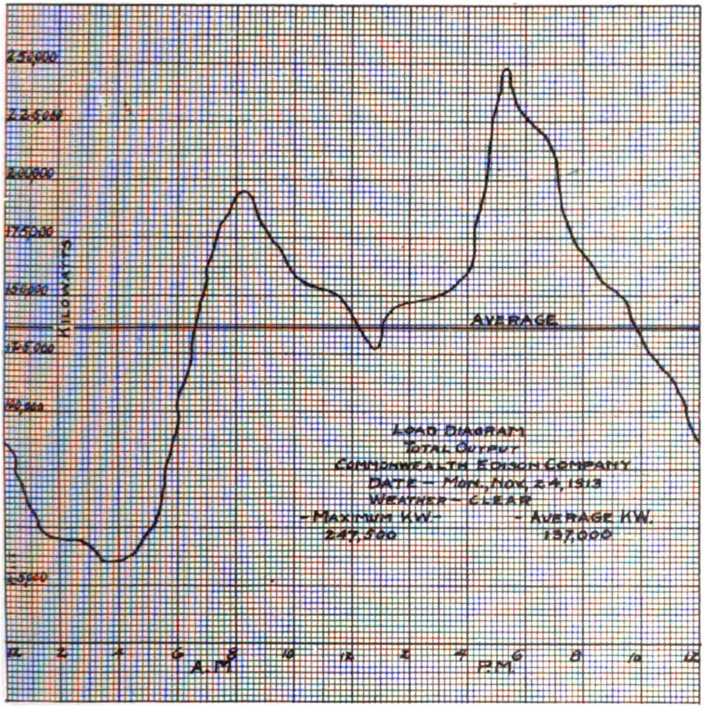
*The National Electric Light Association has defined load factor as the ratio of the average load to the connected load. However, in the next N. E. L. A. Handbook this definition will be changed to consider the maximum instead of the connected load.



Curve Showing Total Load Output of All Stations for an Average Day. Peak at 5:15 due to Railway Load.

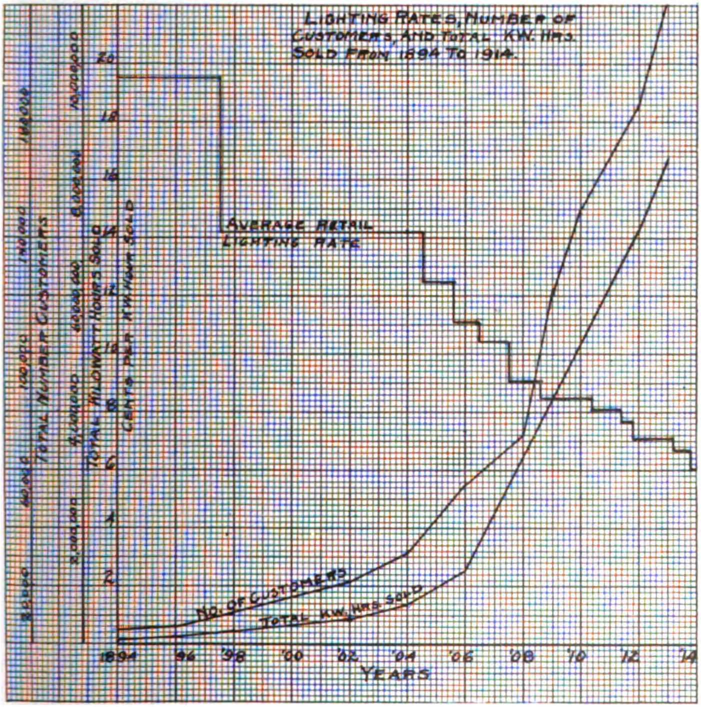
By carefully considering the load factor of the load to be connected, and its diversity with other connected loads, the output of the central station may be increased greatly without increasing station investment.

The fundamental step taken by the new business or commercial department of the central station company is to establish a just rate system. Rates must be charged for any particular class of service in proportion to the cost to the central station of supplying that service. Most large central station companies charge for service according to the Hopkinson and the Wright systems, or a modification of these systems, making use of a double sliding scale of rates both on the consumers' maximum demand and on the K. W. hr. consumption.

Central station business is commonly divided into two main classes, light and power, and subdivided into residence, commercial, and industrial business. To handle the business with the customer, the company employs light salesmen and power salesmen. Each salesman or solicitor is given a particular district with definite limits in which to work, and all calls or applications for light or power which are not taken at the counter or over the telephone, are turned over to him. These salesmen usually receive a salary and commission on the new business secured in their district. The Commonwealth Edison Company at the present time employs 36 light solicitors, two sign solicitors, with several assistants, and 18 power salesmen with four assistant power salesmen. It is the duty of the light solicitor to secure contracts for all kinds of lighting, small power such as fan motors and electric washers, and to give estimates on small wiring jobs of less than six outlets. Larger wiring estimates are handled by the estimating department. A ruling recently passed by the company, requires an applicant for a position as assistant light solicitor, to spend six months in the illuminating department. Of the 18 power salesmen, only 12 have regular assigned districts. The other power men work on special power problems, such as isolated plants, electric vehicles, electric railway, and general power questions.

The contract department works hand in hand with the salesmen in securing new business. Several per cent. of the net earnings of the company are set aside each year for advertising electric service by means of elaborate electric signs, illuminated billboards, street car cards, mail matter, and "ads" printed on the bills submitted by the company. The bulk of this advertising applies to residential business, though good results have been obtained through the use of booklets published by the National Electric Light Association to advertise electric service.

The residential business of the company has been considerably increased through so-called "house wiring campaigns." For several weeks, existing unwired houses on the company's lines are wired at cost. As an added inducement to obtain this business, an electric iron is sometimes given with each contract for wiring obtained during this campaign. The wiring may be paid for in 24 monthly payments and may be done by the central station company or turned over to local contractors. Considerable discussion has arisen on this point and may be most satisfactorily settled in specific localities. Some central station companies report the securing of contracts for as many as 80 per cent. of the available residential buildings through house wiring campaigns.



Curves showing the profitable result to the Commonwealth Edison Co. of systematized commercializing of electricity.

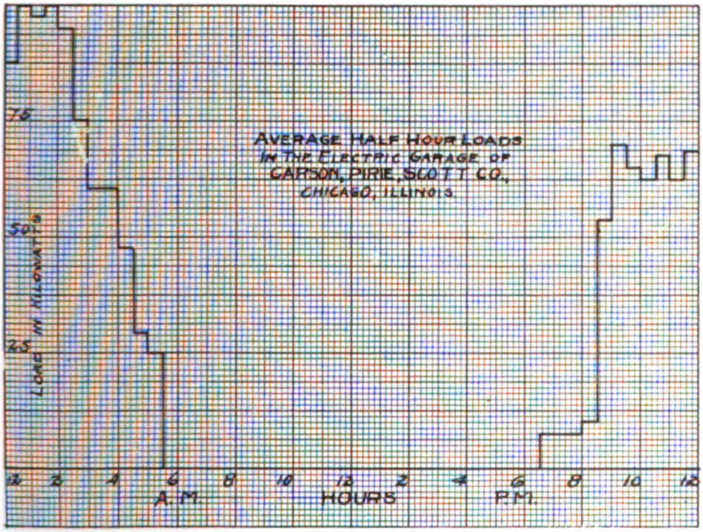
Next in importance to the wiring campaign is the appliance campaign to increase the load factor and total consumption of residential customers. In these campaigns, special emphasis is put on one particular appliance which is most easily introduced, commonly the electric iron. The Commonwealth Edison Company appropriated 15,000 dollars to be used in an electric iron campaign which was launched in March, 1913. As a result of this campaign 12,000 electric irons were put in service in 60 days, and at the present time in Chicago, one out of three residence customers uses an electric iron. The revenue from each iron is approximately 40 cents per month, which is an increase of 20 per cent. in the customers' bill. This spring a campaign on electric percolators will be launched in Chicago.

Before leaving the residential side of the new business, emphasis should be placed upon the importance of a simple method for the residential customer to secure service. It is natural for this type of customer to hesitate to place a contract for service when he feels that there is a great amount of "red tape" connected with it. A simple system employed by the Commonwealth Edison Company in handling this class of customer is to take the application over the telephone and mail the contract to be signed after the service has been connected.

Contracts of various types for commercial lighting, such as small stores, have been put into effect by the Commonwealth Edison Company from time to time. The general principle of using contracts for standard street posts, electric signs and fixtures on a rental basis has worked satisfactorily with small stores, saloons, etc. These contracts usually cover a period of two years to guarantee the Company sufficient revenue to pay for the wiring.

In securing an industrial power load, more complex problems must be handled and the minute details of the load to be connected are considered. Whether or not a particular industrial load is secured for the Company, depends chiefly upon the power salesmen and the rate offered by the Company for that particular class of business. Rates for power are based upon maximum demand, load factor, total consumption, and nature of operation—whether or not the connected load comes on the peak of the Company's load. The power salesmen offering to furnish service to replace an industrial power plant or engine makes a complete analysis of the present installation before submitting a proposition. He knows more nearly what the manufacturer pays for power than the manager himself. The clever salesmen, with a good knowledge of the operating conditions of the industrial plant, usually is able to secure this load for the central station by offering a fair rate and good service.

Large power installations require special rates and often special sub-stations. Considerable data has been collected in the last few years on application of central station serv-



ice for operating coal mining and ice machinery, irrigation and oil pumps, and air compressors. The important advantage of a vehicle battery load has been noted. Special conditions are met with in each of these applications, and the details of operation and characteristics of the load curves are carefully studied. These investigations have resulted in securing for the central station a large portion of the available business of this nature, especially in the middle west.

One of the most attractive loads for the central station is the ice machinery load. The load is fairly constant and comes on early in the morning to fill in the valley of the station load curve. Another advantage of this class of business is its season diversity with respect to the higher winter load of the station, as its consumption during the summer months is much greater than in winter. Coal mines, irrigation, and oil pumping loads are especially attractive to companies operating a system of transmission lines through rural districts, since long line extensions are not usually necessary to connect the load. The electric service company which has been perhaps most successful in securing an oil pumping load, is the Oklahoma section of the Middle West Utilities Company. The power engineer of this company expects to have secured all the available load of this nature, in the state of Oklahoma, within a few months. The same company now supplies service to several large coal mines in Illinois, and stone quarries in Indiana.

The electric garage business is at the present time commanding considerable attention from the power engineers of all large public service companies. This class of business has been given little consideration and, due to the efforts of the electric vehicle manufacturers, has increased until it promises to be one of the most important loads a station may secure. The electric vehicle is used not only for pleasure, but also for trucking purposes. This load is perhaps more attractive to the central station than the railway load, since the batteries may be charged on an off peak schedule and thereby raise the station load factor. Chicago leads every other city in the world in the number of electric vehicles. Two prominent department stores in the city use respectively 158 and 59 electric trucks for delivery purposes. Practically all the trucking for the Commonwealth Edison Company is done with electric trucks. On January 1st, 1914, there were 702 electric commercial trucks in service in Chicago, and nearly 3,000 passenger vehicles. Electric heating appliances for industrial purposes are coming into general use, also, especially electric glue pots, welders, and furnaces. The use of these appliances promises to become as general as the common electric household appliances.

In this article, I have outlined in a general way, the problems that confront the commercial or contract department of a large central station company. A systematic study of these problems, such as has been and is being made by the various large central stations is certain to bring results. That the results obtained by the Commonwealth Edison and allied companies have been strictly satisfactory is shown by the accompanying curves.

THE CYCLECAR

H. A. HUEBOTTER, '12

Economy in maintenance and operation of the motor car is a characteristic which prospective owners are demanding more and more insistently of automobile manufacturers. This same demand has been heard in Europe for years, owing to the exorbitant price of fuel existing there. When gasoline sells at $1.02 per gallon, as it did in England in 1912, the average motorist requires that one gallon carry him farther than the ridiculously low distance of 12 miles as is a fair average in America. Judging from the indications of the past two years similar fuel conditions will soon be approached in the United States. The rising cost of gasoline has been offset in Europe by an increased efficiency of the car. In average commercial car practice the vehicle weight is very close to the carrying capacity. The ordinary two passenger roadster of America weighs anywhere from 1500 to 3700 pounds and provides transportation for a load of 300 to 400 pounds exclusive of equipment. This means that 80 per cent. or more of the fuel is spent in moving the bare car and the cost per passenger mile appears enormous. European designers have reduced the rate of car weight to load in order to cut the overhead cost of running. The change has been accomplished gradually—so gradually as to occasion great comment in neither Europe nor America. The general trend of the current automobile design was followed and the small car slowly developed from the large one. In France, however, one designer worked out an original idea and the Bedeha was created. The newspapers and journals exploited it as a freak and a joke and spread the news of the first cyclecar throughout the country. The machine was propelled by a "V" type twin-cylinder, air-cooled motor set longitudinally in the frame. The power was transmitted through a single chain to a jackshaft, thence to the rear wheels by "V" belts. Steering was by hand wheel through shaft, bobbin, and cable to a pivoted front axle. Tandem seating with narrow tread completed the unique features of the design. The car showed speed, reliability, comfort and economy, and became popular. It was copied and developed and took the name of cyclecar.

But what is a cyclecar? What is there about it to distinguish it from an automobile? The European cyclecar is limited in piston displacement to 1100 c.c. (67 cu. in.) and in chassis weight to 672 pounds. It may have either three or four wheels. These restrictions as to cylinder capacity and car weight do not apply in the United States and a revision of the definition is now under discussion in England. At the first meeting of the Cyclecar Manufacturers' National Association held in Chicago January 27, 1914, a classification was adopted in order to show each manufacturer his standing in the cyclecar world. Under this ruling the cyclecar is a four wheeled vehicle of which the maximum piston displacement is 71 cu. in. and the maximum total weight with tanks empty is 750 pounds. The light car class includes those machines with a motor capacity of 71 to 100 cu. in., and a weight of 750 to 950 pounds. The small car has a 100 to 125 cu. in. motor and a weight of 950 to 1150 pounds. This largest car is far below the present small automobile in size. Nothing has been decided yet as to general standards of tread, seating capacity and arrangement, or design of any description. The indications at present, however, are that the cyclecar class will be composed of cars fitted with air-cooled motors of nearly maximum size, friction or planetary change-speed gear and probably belt drive. The true cyclecar obviously should be built as simple as possible compatible with safe and effective performance. In the cyclecar the effort has been made to combine the best features of both the automobile and the motorcycle, in a four wheeled, two passenger vehicle. Some designers have started with the automobile, others with the motorcycle; still others have begun with the intention of building a car light, simple, fast, safe, comfortable, economical and reliable, have selected such parts of the automobile and the motorcycle as would best meet their requirements and have combined them in conjunction with parts peculiar to their own creations.

In the matter of expense, both initial and operating, the cyclecar is far lower than the average small automobile and but slightly higher than the motorcycle. Gasoline consumption runs about one gallon for 35 to 40 miles. Tire cost is low, standard motorcycle tires being the usual equipment, of which the full set can be obtained at a price below the ordinary touring car case. The wear on the tires is slight, for a cyclecar with the 28 inch by 2½ inch size is overtired. A cyclecar, to be satisfactory, must possess several features to a degree at least as great as the automobile. The machine being new, will be subjected to criticism and tests more severe than that accorded the big car. The first impression being the most important, the car should have, first of all, a good appearance with racy lines so universally sought in this type. It should look comfortable, sociable, sturdy and safe, and, above all, finished. The machine having created a favorable first impression must be capable of supporting it in performance. It must show speed with easy riding and must be quiet both in exhaust and in moving parts. In order to be economical in operation as well as to have the desired speed, the weight should be reduced to the minimum consistent with strength. The motive power should be properly proportioned, for if excessive the fuel consumption will rise quickly and the various parts may be overstressed. The most desired quality, reliability, should always be borne in mind by the designer, the manufacturer and the purchaser. Without this essential element the low priced car may prove expensive in the end and is sure to be a constant source of annoyance to the owner and the dealer as well as of danger to the passengers.

That the cyclecar has two fields to enter has already been demonstrated. As a pleasure car for two it is ideal. It can travel roads and enter places impassible to the touring car; it can take bad turns, highly cambered, slippery surface, and short choppy bumps at a speed and with a degree of comfort and safety altogether foreign to the auto. For short trips of a single day's duration it is unsurpassed and it is also applicable for touring so far as comfort and road performance are concerned, but the baggage space is necessarily somewhat limited. As a commercial vehicle the cyclecar is filling a long felt want in light package delivery requiring a capacity of 250 to 300 pounds. It is handled well in city traffic, is quicker than any other means used in similar service, and the operating cost is almost negligible. It is by no means a fair weather car, but may be used under all conditions favorable to motor cars. It is especially successful in rainy weather on pavement, for it does not skid on the most slippery asphalt.

The cyclecar of the present is represented by nearly as many different types as there are manufacturers. The endeavor has been to adapt the car to American tastes and American roads. Just how these tastes will be best satisfied is a question of many sides. One thing is certain, European designs will never be popular in the United States. The foreign big car with an appearance that appeals to the average American is a rarity. For this reason the first season will bring forth machines of every description. It will be a period of experiment in exterior design. The cyclecar to date has not a single standard and the establishing of standards will probably be attended with difficulties at the outset.

In the matter of power plants the cyclecar has a choice of about as many general forms as the automobile and the motorcycle combined. On account of light weight requirements the motor is of the high speed type. The true cyclecar will in all probability be equipped with a two cylinder motor, the light car and the small car with a four cylinder. The latter is pretty well standardized from its development with the automobile. The cyclecar on the other hand offers a large field for the various twin cylinder designs. The motor may be of either vertical, horizontal, or "V" type, hung longitudinally or transversely. Of the two cylinder vertical motor, two kinds have been tried out on the early automobiles. That in which both crank pins are on the same side of center has good firing balance but poor running balance. The cycles in each cylinder are one revolution apart, but the reciprocating and the eccentric rotating parts can be balanced through but a small range of speed. Cranks on opposite sides give an improvement in the running, but the cycles occur at unequal intervals—180 degrees and 540 degrees apart. On account of these defects this motor has been abandoned almost entirely in the automobile industry. The twin with the least vibration is the opposed type. The cycles occur one revolution apart and the reciprocating parts, working in opposite directions, set up forces which neutralize one another. Practically all of the vibration is due to the explosions. The chief objection to the opposed motor is its width. The narrow frame of the machine renders transverse hanging difficult. With longitudinal setting the force of each explosion tends either to retard or to accelerate the car, depending upon which cylinder is firing.

The twin "V" bids fair to become the favored two cylinder motor. It is short with a single throw crank and consequently less eccentric weight than the vertical motor.

As ordinarily constructed the cylinders are set at an angle of 45 degrees, but 60 degree and 90 degree angles are not uncommon. The first arrangement is the most compact and has the best firing balance of the three. The last is better balanced kinetically than the others, but fires at intervals of too great variance. It is wide in comparison with the 45 degree motor and has a long inlet pipe, a serious objection in cold weather. The 60 degree motor is a compromise between the two. The firing order of the 45 degree type is 0 degrees, 315 degrees, 720 degrees; of the 60 degree, 0 degrees, 300 degrees, 720 degrees; of the 90 degree, 0 degrees, 270 degrees, 720 degrees. The "V" motors have been well tested and developed in connection with the motorcycle industry, and it was at first thought that the same motor would be equally satisfactory in the cyclecar. The error of this opinion was soon demonstrated. A four wheeled vehicle is expected to travel more slowly on occasion than one on two wheels, and that without changing gears. Consequently the cyclecar motor must contain heavier crank disks to enable it to operate successfully at low speeds. The car puts a much heavier torque upon its motor than does the motorcycle in accelerating. For this reason a comparatively stiff crankshaft is required and rigid connections of the shafts to the disks are essential. A motor which will drive a motorcycle through a plain taper fit of the shaft in the disk will easily shear a 7/32 inch key, augmenting the same fit in a cyclecar.

This heavy torque renders the air cooling proposition more complicated with the cyclecar. A fan with free circulation of air must be provided. The usual form of air cooling without jackets is not likely to be practicable with any but the "V" motor. Four cylinders, even with the best air jackets and forced draft, have a decided tendency to overheat as has been proved conclusively in automobile practice. The water cooled four cylinder motor has the greater popularity and will in probability keep it, unless radical improvements are made with the air. The experience of the early motor car manufacturers offers much of value to cyclecar designers.

In the ignition system the cyclecar was found again to break away from motorcycle precedents and teachings. Since the "V" motor fires at unequal intervals the high tension magneto, if used, must be geared to half crankshaft speed. For this reason the motor will not run well at low speeds since the spark is not sufficient to fire the mixture. Besides the low speed is the fact that the interrupter cannot break contact at the point of highest voltage for both cylinders. The error is split between the two cylinders, making one fire 22½ degrees before, the other 22½ degrees after the ideal point, measured on the armature travel. This reduces the voltage approximately 30 per cent. and, combined with the gear reduction, gives poor ignition for starting and slow running. The usual arrangement for cranking the motor on the magneto by hand is the provision of a two or three to one gear between the starting crank and the crankshaft in order to obtain sufficient speed for a spark. By far the most common type of ignition for this motor is by high tension battery system with non-vibrating coil. The same device is usually fitted to the small four cylinder also, although here the magneto is perfectly feasible.

The speed and torque control of the cyclecar is provided for in the same ways as used in the automobile. In the former, however, the friction drive leads in popularity on account of its simplicity, absence of noise, and its smooth action. The power transmitted is not great enough to require frictions of excessive diameter and the chief objection to this drive is therefore overcome. The danger of rapid wear due to overloading is absent and the possibility of selecting the exact gear ratio required to drive the car over any road encountered appeals to the careful operator. The friction may be located in one of two places—either ahead of the dash next to the motor or under the seat. Both places have their advantages, as will be brought out later. The sliding gear and the planetary transmissions have been adopted by some manufacturers. The former is used principally with the four cylinder motor. The planetary gear has always carried the objection to the noise produced by the pinions rotating at the high speed required. This is especially noticeable in the cyclecar where the high speed motor is the rule. Either of these transmissions may be placed in a housing bolted to the motor or to the rear axle or carried between the two.

The drive from the change speed gear to the rear wheels is usually one of three standard types—chain, shaft or belt. The first is not common in the United States, but has met with considerable success in England where the single chain adherents are strong. The shaft drive is used in conjunction with the sliding and the planetary transmissions. It connects with the live rear axle through two bevel gears or worm and worm wheel. The cars fitted with the final shaft drive are practically all out of the cyclecar class. The transmission most popular among cyclecar designers is the double "V" belt from a jackshaft to each rear wheel. This gives a flexible connection to the wheels and thus saves the tires from the strains occasioned at times by a positive drive. A wide difference of opinion exists regarding the correct method of applying the belts. Some designers favor a long distance between pulley centers in order to secure a large arc of contact on the driving pulley. Others prefer the short belt to eliminate sideslap and vibration. The belt has demonstrated its practicability under the most adverse road conditions in water, mud, snow and dust. The ordinary leather belt must be driven about 100 miles before the stretch is all out of it, but the non-stretchable type in which two strands of steel cable are built into the belt between two plies of leather seems to have overcome this objection. Other belting materials which have been used with more or less success are rubber covered canvas and steel chains lined with friction fabric. With the use of the double "V" belts the differential is dispensed with, giving greater simplicity.

The steering of the early cyclecars was through bobbin and steel cable. This arrangement was simple, effective and reliable, but the general public showed such distrust in the device that it was discarded for some one of the standard automobile types. The rack and pinion gear predominates, although the worm and sector is very nearly as popular. The Ackerman linkage to the front axle is used almost exclusively, except in the few rare instances in which the front axle is pivoted in the center.

The riding qualities are dependent largely upon the spring system. The cyclecar is often fitted with springs of design peculiar to itself, but standard automobile suspensions are more popular at present. This is probably due to the fact that these types have been tested so long that the public has confidence in them. Of the various systems the full elliptic, three-quarter elliptic, semi-elliptic, and cantilever are all in use. The cyclecar springs of special design are of simpler construction and include the helical and the transverse springs. The latter may be swung over the axle or it may be used as a substitute for the axle. Whatever the shape, the springs must have clearance to permit of the use of a light scale. A flexible spring with little unsprung weight allows the wheels to take sudden jars without affecting the motion of the body. It is this feature that enables the cyclecar to run away from the automobile on a corduroy road.

The seating arrangement depends largely upon the opinions of the designer. The tandem method gives slightly better balance with one passenger in the car than does the side-by-side. The difference, however, is not noticeable to the occupant. This doubtful advantage is offset by the greater sociability attendant upon the latter plan which seems to be favored by general opinion. Staggered seating, which is not widely adopted, is a compromise between the two. The method of seating naturally determines the width of the body which in turn influences the tread. Thus, unlike the automobile, the cyclecar is built with a diversity of treads. The same condition prevails in Europe, but there the highways are so improved that there is no reason for following the beaten tracks as is the custom in America. Here the aim is to adopt a tread that will allow one wheel to take the wagon track and the other the horse track. This condition is best met by a tread of 36 to 40 inches.

ALTERNATOR REGULATION

D. LINDER CURTNER, '11

If the load on an alternator is increased, while the speed and excitation are maintained constant, the terminal voltage will in general decrease. Conversely, when the load on the alternator is reduced the terminal voltage will, in general, rise. The rise in voltage, when full non-inductive load is reduced suddenly to no-load, expressed as a per cent. of full load voltage is called the inherent regulation of the machine, with constant speed and full load excitation maintained. The predetermination of the impedance drop, armature reaction, voltage regulation, and field excitation at various loads and power factors from the dimensions of the machine falls under a single head and constitutes a very important problem in alternator design.

After the alternator is built it is not always possible to test it accurately at the factory, principally because of the difficulties of driving, loading, cost of such testing, and the modern tendency toward large units direct connected to the prime mover. Very frequently the alternator and prime mover are built by different companies and are brought together only when installed in the generating station, where the facilities for accurate testing are not always favorable. For the above reasons the testing at the factory usually consists of taking the open circuit characteristic or saturation curve, the short circuit characteristic, a heat run, and measurements of resistance of the windings.

The saturation curve may be readily calculated from the dimensions of the magnetic circuit, the flux density, and the B-H curves of the materials used. In predicting voltage regulation, we are principally concerned with the excitation required for the air gap, teeth, and slotted portion of the magnetic circuit, since the magnetomotive force required for the pole shoes, pole cores and yoke is not effective in forcing flux into the armature but is effective only in overcoming the magnetic potential drop in the above mentioned parts. The ampere turns required for the air gap may be calculated by determining the permeance and flux of corresponding areas. Thus one may select a slot pitch as the area, at the center of the pole. Let

$P_3 = \frac{1}{2}$ air duct permeance
$P_1 =$ permeance from tooth top to pole
$D =$ air duct width
$P_2 = \frac{1}{2}$ slot permeance
$P = P_1 + 2\,P_2 + 2\,P_3 =$ permeance per slot pitch
$\delta =$ air gap length
$s =$ slot width
$t =$ tooth width
$l_n =$ net axial length of armature
$n =$ number of air ducts

Remembering that permeance is the reciprocal of reluctance, one may write the following equations:

$$P_1 = \frac{t\,l_n}{\delta}$$

$$2\,P_2 = \frac{4\,l_n}{\pi} \log e \left[\frac{\pi\,s + 4\delta}{4\,\delta}\right]$$

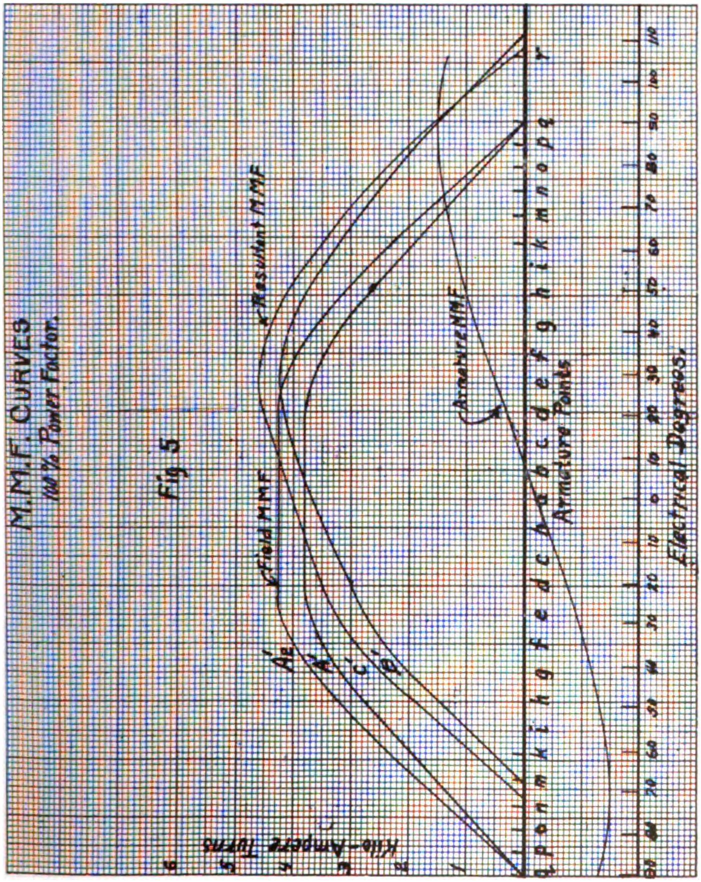
$$2\,P_3 = \frac{4\,n\,t}{\pi} \log e \left[\frac{\pi\,D + 4\,\delta}{4\,\delta}\right]$$

$$P = \frac{t\,l_n}{\pi} + \frac{4\,l_n}{\pi} \log e \left[\frac{\pi\,s + 4\,\delta}{4\,\delta}\right] + \frac{4\,n\,t}{\pi} \log e \left[\frac{\pi\,D + 4\,\delta}{4\,\delta}\right]$$

Considering that the flux passing a given area (in this case a slot pitch) is expressed by $\phi =$ m.m.f. P, or $\phi = .4\,\pi\,NI\,P$, it is relatively easy to show that the ampere turns (NI) required for the air gap at the center of the pole face where the lines of force are sensibly parallel are expressed by

$$NI = \frac{\phi}{.4\,\pi\,P} = \frac{B\,A}{.4\,\pi\,P} = B\,K,$$

Where B is air gap density, A = area of a slot pitch, and K = the constant $\frac{A}{.4\,\pi\,P}$. By the use of this expression it is easy to calculate the air gap ampere turns required at any air gap density. It is also equally plain that a curve plotted between NI and B will be a straight line. The calculation of the excitation required for the teeth and slots is so obvious, since it follows from the expression Hl = .4 π NI, the radial length of tooth l, and readings taken from the B-H curve of the material, that more detail will not be given it here. The sum of the excitation required for the air gap,



M.M.F. CURVES
100% Power Factor.

Fig 5

and teeth and slots plotted as abscissae against air gap density or generated voltage as ordinate gives the saturation curve desired. The air gap permeance is not constant from all portions of pole to armature but varies according to pole shaping and dimensions.

The drop in voltage caused by the flow of current in the armature conductors may be divided under two heads—

(a) The impedance drop, made up of the resistance and reactance drops,

(b) The armature reaction or neutralizing effect of the armature ampere turns upon the field ampere turns.

The magnitude and effect of the impedance drop varies with the load and power factor of the load on the machine. At unity power factor operation, the resistance drop is the predominating factor, but as the power factor reduces, the reactance becomes of more importance. The resistance, being a function of the cross-section and length of the conductor, as well as the temperature at which it operates, is easily calculated. The reactance is directly proportional to the inductance of the machine. The general scheme for calculating the inductance of the armature winding may be outlined as follows. Divide the winding into the imbedded and end connection portions. Calculate the flux linkage of the end connections per pole per phase by using the transmission line formula between appropriate limits. Calculate the flux linkage per pole per phase of the imbedded portion produced by the flux passing across the slot and also that due to the average flux passing from tooth top to tooth top. The sum of these flux linkages per ampere of current multiplied by the number of poles and divided by 10^8 gives the coefficient of inductance per phase in Henries. Such modifications as are necessary to adapt this general scheme to the case in hand are always permissible.

The magnitude and neutralizing effect of the armature ampere turns also varies with the load, on the assumption that the voltage remains constant and current varies, and the power factor of the load on the alternator. This leads to the calculation of the magnitude, and to the determination of the position of the armature m.m.f relative to the field m.m.f. The m.m.f. of a loop of wire is always perpendicular to the plane of the loop, or if the turns do not all lie in the same plane, the m.m.f. will be perpendicular to the resultant of the group of turns. The voltage of rotation will be a maximum where the flux is a maximum. Hence if the voltage and current waves be assumed sinusoidal and in phase, the maximum will occur when the coil is passing the center of the pole, and O B in Fig. 4 indicates the direction of the armature m.m.f. of phase No. 1. Thus if the current is in phase with the voltage, the m.m.f. of the coil is 90° out of phase with the voltage of revolution, and also 90° out of phase with the field m.m.f. In this position it will be noted that the armature reaction is entirely distorting in its action. When the plane of the coil is at right angles to the field, the current in the armature conductor is zero, hence when in position to demagnetize the field, the armature m.m.f. is zero. With power factors other than unity the maximum of the voltage and current waves does not occur at the same instant, so that with lagging current, the position of the armature m.m.f. will be 90° plus the power factor angle out of phase with the field m.m.f. as shown in Fig. 8, and for leading current the phase angle between field and armature m.m.f. will be 90° minus the power factor angle. The magnetizing or demagnetizing effect of the armature m.m.f. is much greater, as is evidenced by a comparison of Fig. 5 and Fig. 8.

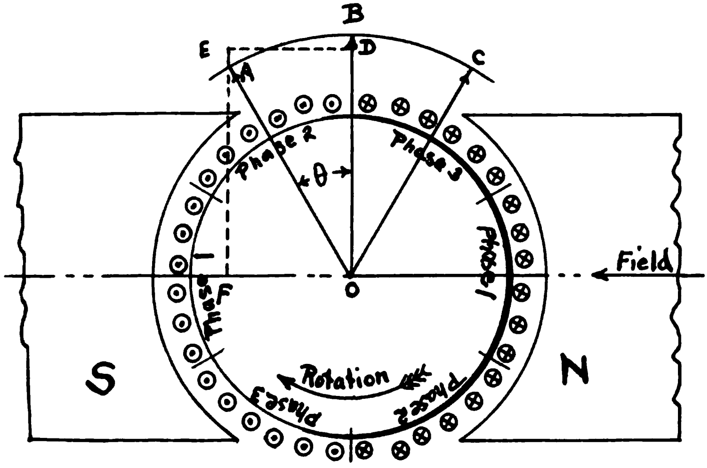


Fig. #4.

It is desirable to know the shape and magnitude of the armature m.m.f. Let the discussion here be limited to a three phase alternator and for simplicity of demonstration choose a two pole machine.

Since the winding of one phase of a three phase machine is spread out over $\frac{\pi}{3}$ electrical degrees, it becomes necessary to sum up the components of field due to each turn into a common direction, OB, Fig. 4. Reducing the calculations to the armature ampere turns per pole in terms of one phase the procedure is as follows:

Let T = turns per pole per phase = OB

$$\text{Area AOB} = \int_0^T \int_0^{\pi/6} P\,d\,P\,d\,\theta = \frac{T^2\,\pi}{12}$$

$$\text{Area AOF} = \frac{T^2}{2}\left[\sin\frac{\pi}{3}\ \text{Cos}\,\frac{\pi}{3}\right] = .2165\ T^2$$

$$\text{OF} = \text{T Cos } 60^\circ = .5\ \text{T}$$

$$\frac{\text{Area AOB} + \text{Area AOF}}{\text{OF}} = \text{OD} = \frac{\frac{T^2\,\pi}{12} + .2165\ T^2}{.5\ T} = .955\ T,$$

which is the summation of the projections of OA on OB as θ varied from $\frac{\pi}{6}$ to zero. If the current wave is sinusoidal the instantaneous value is

$$i = I_m \sin a$$

where i is any instantaneous current valve, I_m is the maximum current value and a is the electrical angle. Then the summation of the armature ampere turns for phase No. 1 at any instant is,

$$NI_{1a} = .955\ TI_m \sin a$$

A similar expression will suffice for phases No. 2 and No. 3 if to a is added the angular difference between the phases. Then for phase No. 2,

$$NI_{2a} = .955\ TI_m \sin (a + 60)$$

and phase No. 3,

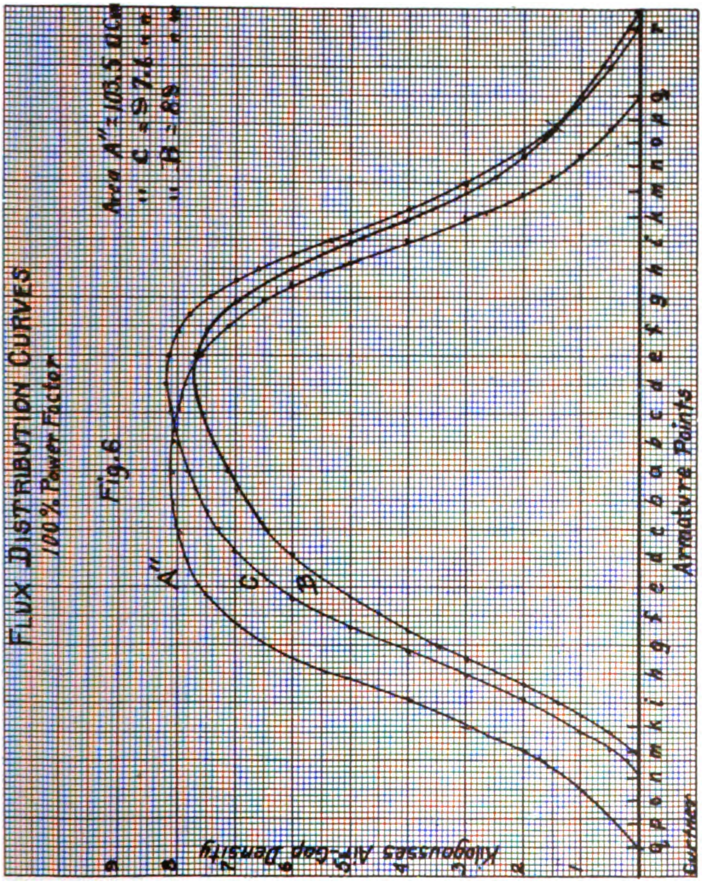
$$NI_{3a} = .955\ TI_m \sin (a - 60)$$

Adding and simplifying the expressions for phases No. 1, No. 2, and No. 3, the armature ampere turns per pole are,

$$NI_{ta} = (2)\ (.955\ TI_m \sin a)$$

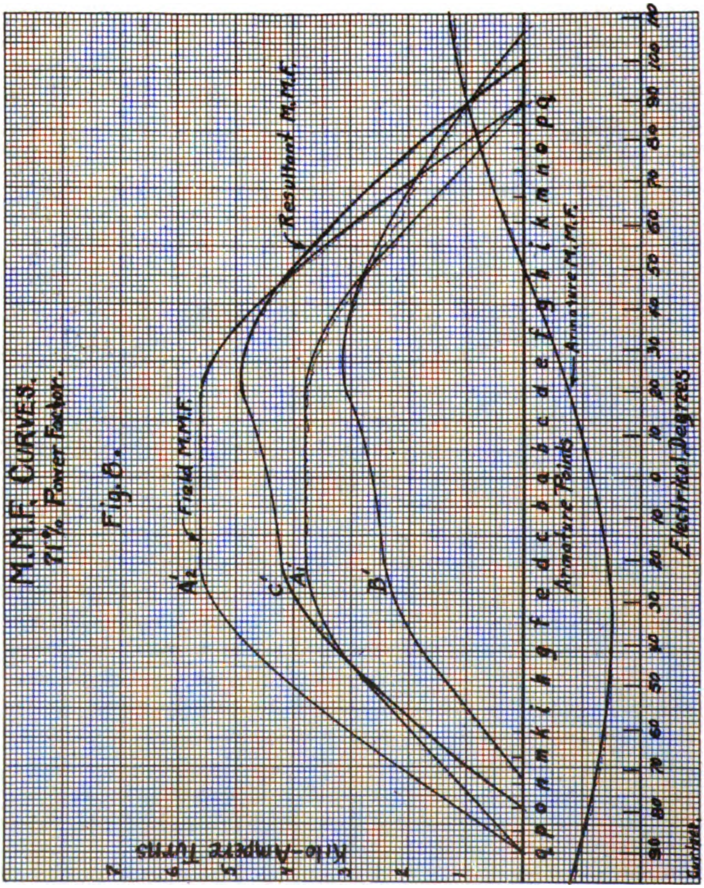
Under these conditions it is shown that the curve of armature m.m.f. obeys a sine law and is of the magnitude indicated by the equation. A similar development of machines of any number of phases results only in a change in the constant (2) (.955).

The magnetomotive force of the field must be sufficient to neutralize the effect of armature reaction and also set up flux entering the armature in amount proportional to the generated voltage, if the speed is to be maintained constant. The amount of distortion and demagnetization or magnetization caused is proportional to the relative strengths of the field and armature m.m.f., the power factor of operation, and the degree of saturation of the armature teeth. This is shown to a marked degree by the comparison of the areas of curve B (69.4 sq. cm.), Fig. 9, where the power factor is .71, and curve B (89 sq. cm.), Fig. 6, where the power



factor is unity, also by comparison of the B' m.m.f. curves, Fig. 8 and Fig. 5, for the above B curves respectively.

A concrete example of a 300 kv.a., 200 r.p.m., 36 pole, 2200 volt, 60 cycle, 3 phase, Y connected alternator will probably serve to elucidate the foregoing abstract discussion.


M.M.F. CURVES. 71% Power Factor. Fig. 8.

The no load and full load (unity P. F.) excitation per pole required for the air gap teeth and slots is 3800 and 4250 ampere turns respectively, (see Fig. 5), and the armature ampere turns per pole, maximum, is 150. From the m.m.f. curves C' and A'_2, are plotted the flux curves C" and A" respectively, representing the air gap flux distribution at full load (unity power factor), and a no load flux distribution when full load field is maintained. From the flux curves, just mentioned, the voltage waves may be plotted in polar coördinates, the measurements of which permit the finding of the effective value, the calibration, and hence the regulation. From these voltage curves it is found that the effective value of A″ is 1366 volts, while the effective voltage of C″ is 1310 volts. The impedance drop is 40 volts, leaving a terminal voltage of 1270 volts per phase. The regulation at once follows as $\frac{(1366 - 1270)\ 100}{1270} = 7.56$ per cent.

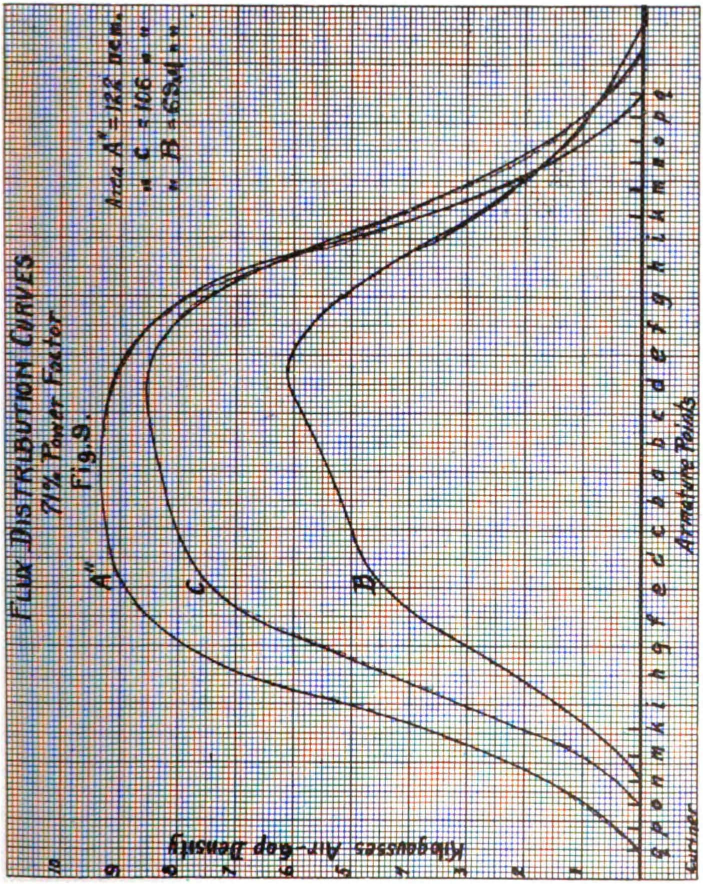


Fig. 9.

Similarly from Fig. 8, Fig. 9, and the voltage wave for .71 power factor we obtain the regulation at .71 p.f. to be $\frac{(1590 - 1270)\,100}{1270} = 25.2$ per cent. The results of test data give the regulation at unity p.f. as 7.5 per cent., while the test data for .71 p.f. is not available.

This method of calculating voltage regulation which utilizes the voltage wave shape as it exists, may be applied to either freak or standard designs, since it is calculated entirely from design data. The results conform reasonably close to those obtained in actual tests.

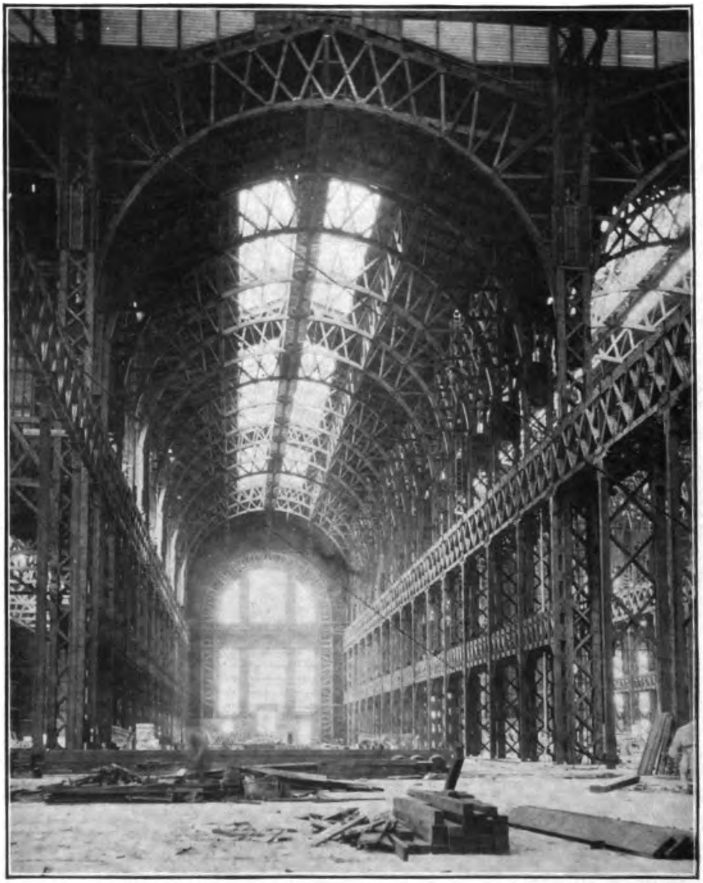
POINTS OF INTEREST DURING THE CONSTRUCTION PERIOD OF THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION

C. H. MUNSON, '11

The Panama-Pacific International Exposition Company was organized by a number of public spirited citizens of the city of San Francisco for the purpose of celebrating the completion of the Panama Canal, an engineering achievement well worthy of some fitting demonstration such as an international exposition. It is the purpose of this paper to give to those interested in engineering and construction work a resume of the various features of interest entering into the activities of the division of works of this company during the pre-exposition period, together with a more detailed analysis and comparison of some of the construction methods in use.

The division of works, which is responsible for the design and installation of all features of construction, is divided for organization purposes into seven major departments—the department of construction, the department of civil engineering, the department of mechanical engineering, the department of landscape engineering, the department of architecture, the department of color and decoration, and the department of sculpture. These various departments each have immediate charge of work pertaining to the planning and development of the special work alloted to them.

In addition to the above major subdivisions there have been created a number of bureaus for the systematic prosecution of the various parts of the work. Among these are the following which have to do particularly with the various details entering into the engineering design and construction activities. The bureau of structural engineering, is responsible for the design and preparation of plans for all structural features; the bureau of building construction, has direct charge of all building construction, directs building inspectors in their duties and makes up monthly estimates of work completed, on which basis progress payments are made; the bureau of estimates, in charge of the writer, has direct charge of preparing all preliminary estimates of cost of proposed structures and also final estimates of cost of the various structures from the final plans as sent out for bids. A more exact statement of the activities of this bureau is given elsewhere in this article; the bureau of specifications, is responsible for the general form and standardization of all specifications; the bureau of engineering construction, handles the force account, establishes grades, makes necessary surveys, etc.; the bureau of water supply and fire protection, has charge of fire protection measures,

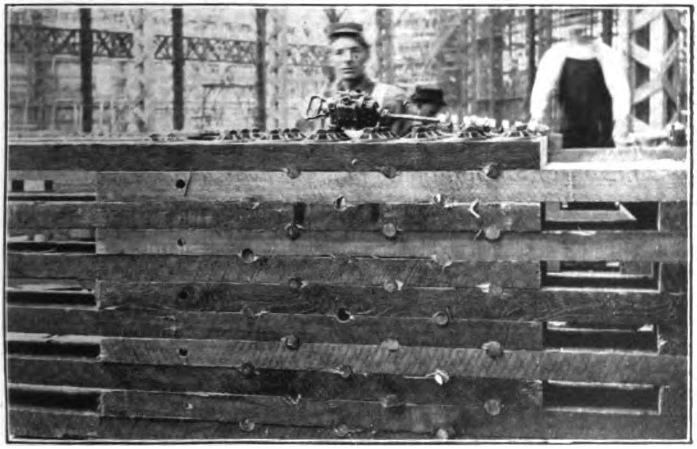


Typical Framing of Machinery Hall. Taken Oct. 28, 1913.

and is responsible for the design and installation of high and low pressure water systems.

In addition to the above there are a number of bureaus which are important, but having a less direct connection with the actual engineering and construction operations, will be only mentioned herein as follows: The bureau of railways, the bureau of illumination, and the bureau of design.

After considerable deliberation on the part of the exposition officials they selected the "Harbor View" lands as the site on which to build the exposition. In conjunction with these lands there will also be used a certain portion of the Presido Fort Mason Military Reservation. These lands front on the bay and afford an exceptional view of the bay and surrounding land. The maximum height of the site selected is 82 feet above sea level, though most of the land is flat. On three sides the site is backed by high hills, which in themselves have caused no end of talk and discussion regarding transportation facilities during the exposition period.



Typical Splice in Main Truss Supporting Dome of Palace of Education.

The preparation of the selected site for the commencing of building construction was in itself no small undertaking, since there were required about 1,700,000 cubic yards of fill. This fill was accomplished by hydraulic dredges at a cost of 301,000 dollars. As the main portion of the buildings erected by the Exposition Company are located on this fill it has been necessary to use piles for the main foundations throughout, and four of the main buildings have their floors supported on piles.

The major portion of the buildings will be of timber construction, although a few will be framed in steel. The construction of the buildings will require the use of about 70,000,000 feet of lumber. In order to standardize the work of design, the following table of allowable stresses for timber was issued to all designers.

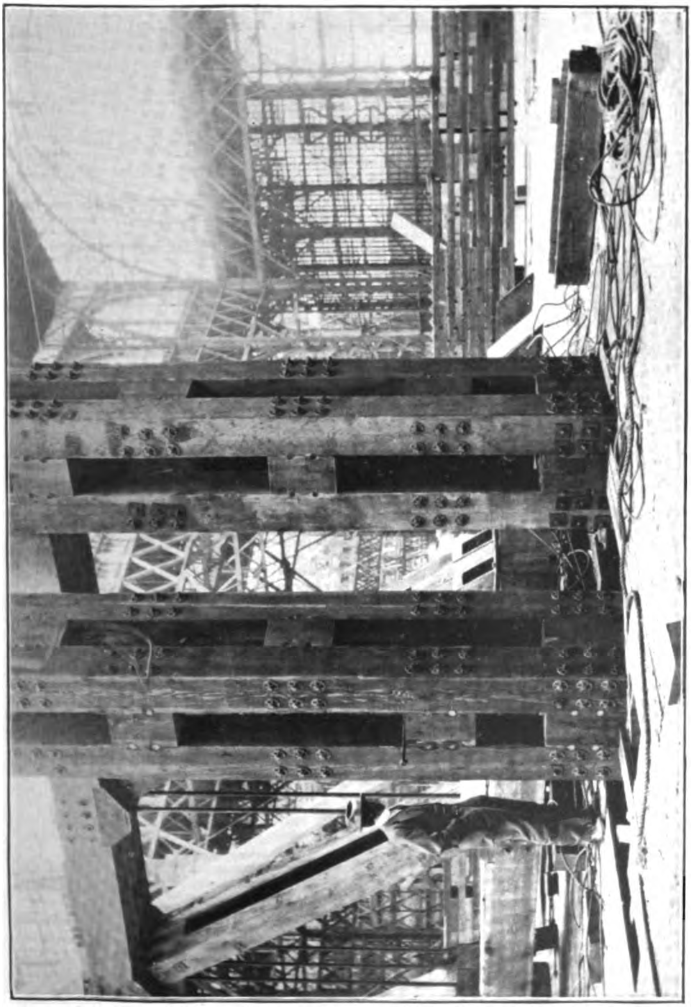
(FOR DOUGLAS FIR)

End compression	1600 lbs. per sq. in.
Compression across fibre	350 lbs. per sq. in.
Shear parallel to grain	150 lbs. per sq. in.
Tension	1200 lbs. per sq. in.
Bending-transverse fibre	1500 lbs. per sq. in.
Columns	p-1600 (1-1/60 L/D)

The wind loads used in design on walls under 150 feet in height were taken at 20 lbs. per sq. ft. of exposed surface; on interior courts, 10 lbs. per sq. ft.; on roofs, 30 lbs. per sq. ft. in a horizontal direction, and for sloping roofs reduced by Duchemin's formula. The stresses in steel members were taken according to Ketchum's "Mill Buildings" specifications; 16,000 lbs. per sq. in. tension. All rods in trusses were given 3000 lbs. initial tension, and all stresses increased 25 per cent. for wind. The details in timber design call for more attention than in steel design since there is no handbook of standards for timber connections such as the Cambria and Carnegie handbooks for steel, and to reduce this work to a minimum the bureau issued a sheet showing the various standards to be used. During the design in timber framing it is also necessary to inspect the work with a view to using sizes of material which are most easily and economically obtained in the open market. This part of the work was largely handled on the advice of the bureau of estimates, which bureau prepared all lumber lists and specifications for lumber contracts.

Those familiar with construction work will readily realize the truth of the statement that in building construction when the contract cost of the work ranges from 200,000 to 400,000 dollars, the contractor must plan his work accurately and systematically and be ever on the outlook to see that all false motions are eliminated, if he is to realize the profit which he figured into the contract price.

A few false moves of the fundamental nature, such as over equipment of the work or improper planning of fabrication operations with the attendant result that the erection equipment is permitted to be idle, will soon eat up whatever profit there may originally have been in the contract price



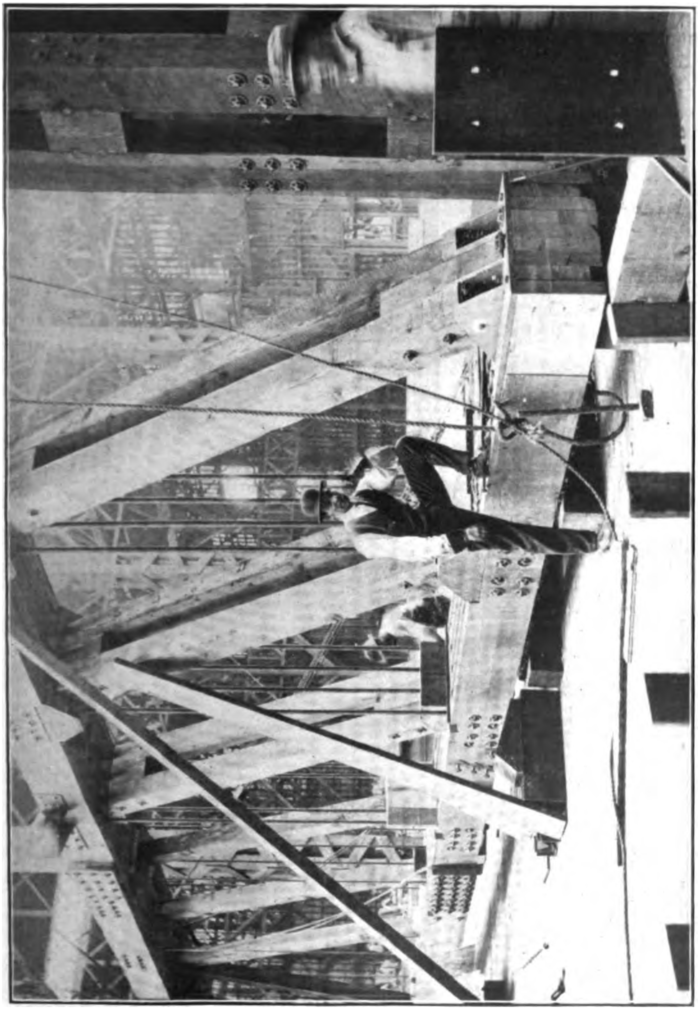
Typical Portion of Four Post Column Supporting Main Truss Under Dome of Palace of Education.

and the contractor who makes these errors may consider himself lucky if at the completion of his contract his books do not show an actual loss on the work.

No where has the writer seen a better opportunity for the comparison of construction methods than is to be had in the construction of the main group of eight buildings. Of these eight buildings, three are under contract with one firm, two with another firm, while each of the remaining three buildings is under contract with a separate firm. It is, therefore, possible to compare the work and methods of five different concerns, each doing the same type of work and working under similar conditions, as regards ground space available for plant and storage of materials, time limitations, transportation facilities, centers of population and the like.

In making comparison of methods used, the reader should recall that the Exposition Company furnished a certain amount of lumber required for the construction of any one building. This is the major portion of the lumber required, and a very carefully prepared detailed lumber list is furnished to the contractor to show him exactly what size and length of material was ordered to cover the lumber required for a given purpose. This was necessary on account of the fact that no two people in preparing a buying list would make the same combination of the various short pieces of lumber required in actual construction. It also should be remembered that due to the limited space available for purposes of storage of material, it was found necessary to insert a clause in the contract providing that a contractor should construct the floor of his building before beginning on other work. By doing this he was enabled to use the floor space for plaster shop, storage of material, etc.

We then have a condition admitting of very little initiative on the part of the contractor up to the time the floor is completed. As soon as work starts on the super-structure we find that there are two general plans of procedure being followed. First, there is the method of placing all material necessary for the various parts of the structure on the floor and fabricating the various columns and trusses in their approximate location, this fabrication being nearly completed before any erection is begun. The erection work is then begun and the construction superintendent gives his time entirely to this operation. Second, there is the method of placing materials on the floor for a small portion of the structure and concentrating the fabricating force on this one particular portion. While this work is going on, the erection equipment is assembled so that as soon as there is a day's work ahead for the erection crew, the work of erection is started, and from this point on the erection crew is not more than a day behind work of fabrication.

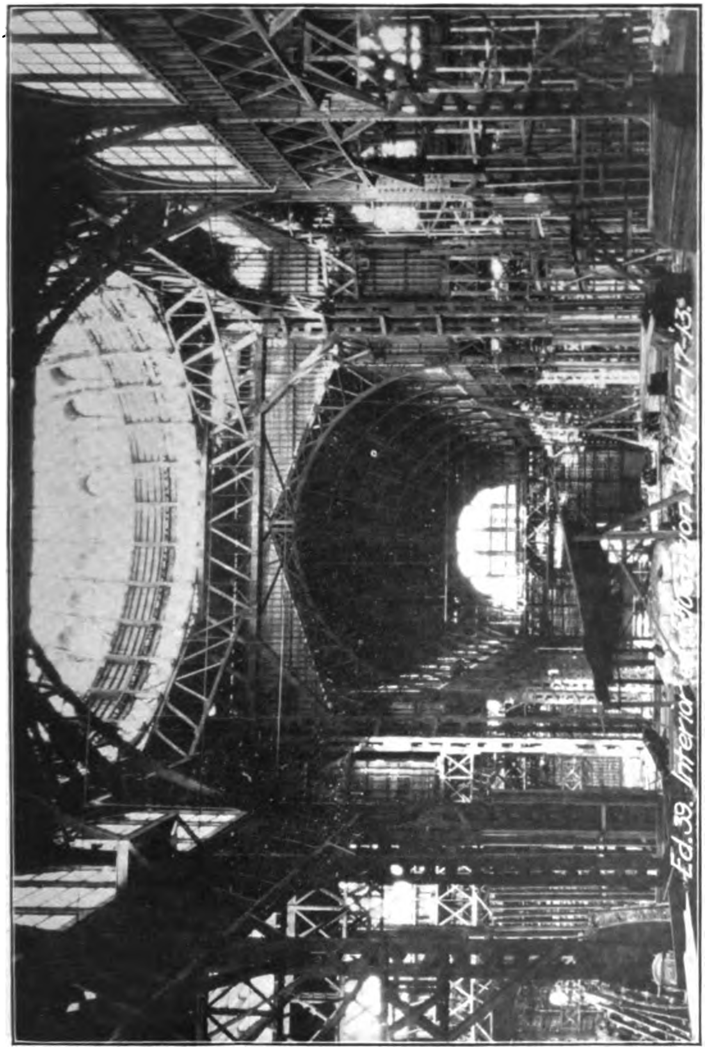


Main Truss "B" which carries one-fourth of the Total Load of the Main Dome of the Palace of Education.

Assuming that those in charge of the work have taken the necessary steps to insure reasonably prompt delivery of materials, the two general methods as above outlined each have their good points. The first method is to be recommended because of the following points: the maximum amount of time is obtained for study of erection methods and equipment to be used; the energies of the contractor and his superintendent may be concentrated on one operation at a time; the chances of delay in the work of the erection crew are reduced to a minimum; the maximum flexibility in fabrication operations is obtained; and the chances of accident to workmen during fabrication operations is reduced to a minimum since there is no danger of accidental injury due to material falling from above. The principal arguments against the first method are as follows: It is to the advantage of the contractor to get the material in place and receive the progress payment on the same; there is little chance of that very desirable rivalry between fabrication and erection crew which tends to expedite the work of each; the first law of the efficiency expert is violated in the fact that there is a lapse in the continuity of the process of construction. In other words, the parts first fabricated lie inert for a month or six weeks after being completed ready for the final operation of erections; and where time is of the essence of the contract, as is manifestly true in the work under consideration, it is quite probable that this method will require twice the outlay in erection equipment that would be required in the second method.

Let us now consider the arguments in favor of the second method: the minimum amount of capital is tied up since the maximum amount of material handled is subject to monthly progress payments; the outlay for erection equipment is reduced to a minimum; the work of fabrication is prosecuted to a maximum speed since delay in fabrication means loss of both time and money in erection. The principal arguments against the second method may be summed in that liability to accident from pieces of material falling from overhead is slightly increased, and delay in the prompt delivery of any one item of material is more liable to cause serious delay in erection and consequent loss of profit on the equipment.

As a rule, it is more reasonable to base one's decision on concrete results than on the intangible, and following this rule it would appear that the second general method should be followed. The foregoing is in the nature of a theoretical analysis of methods and in this connection it is interesting to note actual results as obtained on the construction of the eight main buildings above referred to. Of the five contracting firms doing this work, four followed



Typical Dome Framing Used in Main Group of Buildings.

the first method, and one the second method of procedure; or, in other words, six of the buildings are being built on the first method and two on the second method.

The contracts for the buildings were let in the following order:

1. Palace of Education	March 17, 1913
2. Palace of Food Products	April 9, 1913
3. Palace of Agriculture	April 26, 1913
4. Palace of Liberal Arts	May 20, 1913
5. Palace of Manufactures	May 26, 1913
6. Palace of Transportation	July 14, 1913
7. Palace of Varied Industries	June 17, 1913
8. Palace of Mines	July 15, 1913

The first six buildings in the above list are the ones which are being constructed according to the first method, while the last two are being constructed according to the second method. Of the first six buildings the fourth, fifth, and sixth as shown in the list are distinctly behind the last two, and some feel that it is more than possible that the last two buildings shown in the list will be completed before the second and third are completed. This condition is not entirely due to following the second general method of procedure on the last two buildings, but, in the opinion of the writer, a large measure of the rapidity and general success of this contracting firm is due to the general method which they selected.

In addition to the work of building construction the bureau of estimates also has to deal with the contracts for the construction of sewers, high pressure and low pressure water systems, paving, and electric wiring. The sewers are constructed principally of wood stave pipe for the large diameter and second quality vitrified tile pipe for the smaller sizes. Lap welded steel pipe with converse lock joints is used for the low pressure water system, while for the high pressure water system a heavy grade of lap welded steel pipe with dressed couplings and long radius extra heavy cast iron flanged fittings are used. The electric wiring is of the open knob and cleat type. The material and workmanship will comply with the 1913 edition of the National Electric Code.

In closing this paper it may be of interest to state the following distribution of funds for the construction work as outlined above:

General construction	$2,044,000.00
Mechanical features	492,000.00
Fire protection and equipment	166,000.00
Building construction	5,864,000.00
Decorative features	1,989,000.00
	$10,555,000.00

The remaining $945,000.00 not here accounted for but allotted in the budget for buildings and grounds, is set aside to cover the cost of gardens and planting, operating equipments, administrative expenses of the division of works, and miscellaneous items, such as drinking fountains, seats and benches around the grounds, furniture for the Exposition Company's building, floats for pyrotechnics, small boat landings, freight platforms, etc.

THE INSTALLATION OF A COST SYSTEM

H. E. CALDWELL, '10

The rapid development of our industries during recent years, together with the complexity of their output, is making it necessary for the executive to know exactly what his plant is doing at all times. To meet competition he finds it necessary to know not only what each completed manufactured article costs, but he must know what each part and each operation costs. A comparative study of similar parts or operations often disclose "leaks," which can be eliminated and better manufacturing methods substituted. An analysis once a month or oftener, instead of once a year from the inventory, discloses the dull and busy periods, also the fluctuations in the market. He is thus enabled to redistribute his output more uniformly.

These, and many other conditions, have given rise to cost accounting. It has been rightly said that cost accounting begins where regular accounting ends, and it is largely an engineering problem. When it is applied to an industry with sufficient details, the cost system should give cost per unit for each product; give operation costs; give location and condition of each unfinished job; show amounts of productive labor and non-productive labor, and their distribution; show amounts of productive and non-productive material; show total output by operation; show average output per month; show ratio of expense to productive labor per department; compare operation costs to see if change methods result in net saving; compare total costs per month with sales; and give costs of all goods sold.

There are about as many systems as there are industries, so that no standard system can be given to cover all cases. It is the purpose of this article to give briefly some suggestions that might prove helpful in installing a system.

The first thing necessary is to find out exactly what costs the executive actually wants and needs to know. It is necessary to have his hearty coöperation, for his attitude will affect the rest of the organization, and without it the system would be about as useful as an idle machine in his plant. The abilities and habits of the rest of the organization should be known and utilized, as much as possible.

Habit often means efficiency, and it plays a large part in any industry. Men should be allowed to do the work for which they are best fitted. Caution should be used in creating new departments to satisfy an accounting system. Rather the system should be made to fit the existing conditions. This exact knowledge of the men and the conditions in a plant cannot be acquired easily by an outsider in a short time. Many of the failures of cost systems, after they have been installed, can be traced to this cause. This is why many companies are enlisting the services of their own engineers in the solution of this problem.

The frame work upon which the whole system is built is the chart of accounts. The more care that is taken in getting this as nearly exact as possible, before the work starts, the better the results will be. There should be a chart of general accounts, which may be subdivided as follows:

ASSETS

Cash accounts.
Inventory accounts.
Plant accounts.
  (a) Real estate and buildings.
  (b) Machines and tools.

LIABILITIES

Outside accounts.
  (a) Accounts payable.
  (b) Interest and discount.
Reserve accounts.
  (a) Depreciation on buildings.
  (b) Depreciation on machinery.
  (c) Interest on investment.
  (d) Taxes.
  (e) Repairs.
  (f) Inventory overs and shorts.
Capital accounts.
  (a) Investments.
  (b) Profit and loss.

An operation chart of accounts is also necessary. The plant should be divided into its productive and non-productive centers or departments. Under each department may be listed the operations performed in that department, and as nearly in the order in which they are performed as possible. Care should be used in showing only those operations whose costs it is necessary to know. Otherwise, the office is easily swamped with useless details. Later each department can be subdivided as much as is deemed necessary.

Each department and each operation may contain the following accounts: Labor, fuel, fixed charges, sundries, supplies, and power. Each account in the chart should have an individual number, and this number should be used instead of the name of the account, as it will save a great deal of clerical labor. An example of this kind of a chart is as follows:

Steam Plant

Acct. No.	140	Labor
	141	Fuel
	142	Fixed charges
	143	Sundries

Sheet Metal Department

144	Labor
145	Fixed charges
146	Sundries

Blanking

147	Labor
148	Power
149	Fixed charges
150	Sundries

One of the most important items affecting the true costs, is the proper interpretation and distribution of the values of the buildings and equipment in the plant. These values are placed in the fixed charge accounts. A very good method of obtaining and recording these fixed charges is by the use of the fixed charge sheet. This sheet should show the names, values and rates of depreciation of the various items charged to each operation, and it is very convenient in the handling of future changes of operations or equipment.

Before obtaining the values of the equipment, a plat of the plant should be obtained and the various buildings should be designated by some symbol; i. e., Building A, Building B. Then drawings of the floor area of the different buildings should be obtained. These drawings should show the location of the machines, motors, line shafts, and such other equipment as seems advisable. The machines should all be numbered for purposes of identification and repair record. A very successful method of numbering the machines is to let the first symbol be that of the building, the second the number of the floor, and the third of the machine. Thus, A-2-17 shows that it is machine No. 17 on the second floor of building A. The floor space should be divided into sections; the productive space being charged directly to the various operations, and the non-productive space being charged to the general fixed charge account for the department in which it is located.

In obtaining the physical value of the plant, it is convenient to obtain, where possible, the original value of the various items from appraisals, office records, or unit cost data, and then obtain a certain per cent. of the original value for the present value. The "present value" does not necessarily mean the price for which the owners would be willing to sell the equipment, nor the price that could be obtained by selling to others, nor the cost to produce, but it should represent the value of the equipment to the owners in continuing the manufacturing processes as they now exist. Any change in methods or equipment which can be foreseen, can be taken care of by a greater rate of depreciation.

To avoid confusion, repetition or omission of fixed charge items, it is advisable to group them into separate classes, and to collect the costs of each group separately. Items should be charged directly to operations where possible. If they are common to more than one operation, their value should be prorated. The following shows the method of classifying and obtaining values for the fixed charge sheet:

MACHINES—Includes initial cost, cost of installation, driving belts and countershaft. Charge directly to operation.

FURNACES—Includes initial costs, installation and initial bricking. Charge directly to operation.

BLOWERS—Cost installed. Charge directly or prorate by number of burners.

PIPING AIR AND OIL—Cost installed including mains, branches, storage tanks, stand pipes, and pumps. Prorate by the number of burners.

TRANSMISSION—Cost installed of line shafts, pulleys, driving belts, and motors. Prorate by H. P. of machines driven.

EXHAUST SYSTEMS—Cost installed. Prorate by number and size of outlets.

BENCHES, RACKS AND TABLES—Charge directly to operation or department.

DIES, FORMS, AND SPECIAL TOOLS—Charge directly to operation or department.

TRANSPORTATION—This includes elevators, conveyors, chutes, derricks, trucks, monorails, etc. These should be charged directly to operations where possible, or prorated by floor area to the departments to where they apply.

BUILDINGS—These should be prorated to departments and operations by multiplying the square feet of floor space occupied by each, by the value of the building per square foot.

ILLUMINATION—This includes wiring, lamps, reflectors, and switchboards installed and may be prorated by the watts per sq. ft. of area lighted.

FIRE PROTECTION APPLIANCES—This includes sprinkler systems, trucks, hose, fire engines, pumps and hand extinguishers. These may be prorated by the square feet of floor area protected.

PLUMBING—This includes sewers, water mains, fixtures, etc., and may be prorated by floor area.

GENERAL EQUIPMENT—Items which apply to the whole plant such as office furniture, sheds, pavements, fences, etc., may be charged to a general fixed charge account.

For any given period, the fixed charges of any operation, which did not contain any productive labor, may be added to the fixed charges of its department. The general fixed charges of the departments, and the general fixed charges for the plant may be prorated to the various operations by the amount of the productive labor obtained from the pay roll for that period.

After assigning values to all of the equipment, the next step is to determine the life of each item, or its rate of depreciation. This is the basis on which the replacement fund is established. If the pay roll comes bi-monthly, then each machine or building is depreciated one twenty-fourth of its annual depreciation. This amount is shown on fixed charge sheets opposite each item of equipment. The rates of depreciation should be governed by the existing conditions in the plant, and by good engineering practice. The following rates may be used as a guide:

Machine shop machinery	3–5%	Exhaust systems	20%
Power hammers	10	Sprinklers	4
Tumblers	10	Horses	15
Saws	10	Office furniture	7
Power transmission	7	Benches	5
Electric wiring	10	Fire protection piping	10
Hoists	5	Steam piping	10
Furnaces	8	Water piping	7
Dies	35	Sewer piping	3
Patterns	7	Gas and air piping	4
Trucks	10	Heating system	10
		Buildings	2–10

The interest per year on the investment is prorated by the total value of buildings and equipment for each operation or department. Taxes and insurance may be prorated by the floor area of each operation or department.

In the operation of a cost system, a large number and variety of forms are necessary to keep the various records, and the printing bill is a large item. It is advisable to utilize, as much as possible, the forms already in use, and the size of the new forms should be some multiple of the standard printers' sheets, to avoid waste in cutting. These items are often neglected by cost accountant experts.

The subject has not been fully covered in this article. The method of handling labor accounts, orders, raw material and supplies, and all the other accounts that go to make up the monthly analysis sheet has not been touched. Those items which have been mentioned are ones that must be met by the man on the job, and it is hoped that the suggestions offered may be of some assistance in the solution of similar problems.

A HYDRO-ELECTRIC INSTALLATION IN CENTRAL HONDURAS

V. T. MAVITY, '13

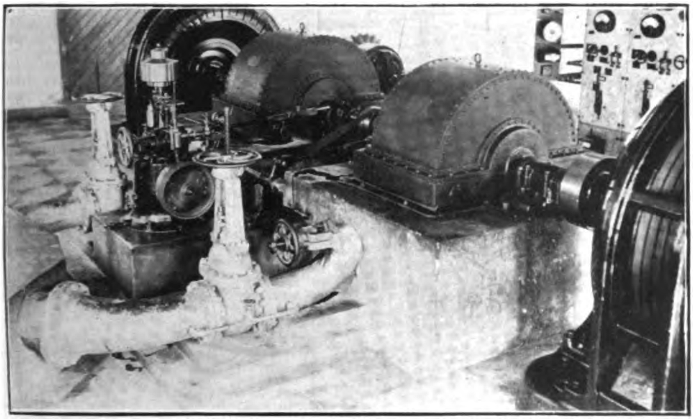
All of the energy that is used in the Rosario Mines, which are located near San Juancito, Honduras, Central America, is supplied by two hydro-electric power stations, one of which is at San Juancito, and the other at Guadalupe, about one and one-half miles north and east of San Juancito. Mountain streams furnish the water supply for both plants. More than a quarter of a mile above the level of San Juancito there are dams across the streams from which the water is carried in wooden canals to the San Juancito water box. The water that is not directed into the canals flows on down to San Juancito, where the two main streams meet and flow past the power station. Just below the station, there is a dam, which directs the water into the Guadalupe canal. The discharge water from the San Juancito plant also flows into the Guadalupe canal and is used again at Guadalupe.

The Escobales flume, from the farthest dam to the water box, is two miles long with a grade of 0.66 per cent. and is two feet wide and 18 inches high. The San Juancito canal is 2½ feet wide by 18 in. high, is 7300 feet long and has a grade of 0.50 per cent. Through these two canals the water flows to a water box of wood construction which acts as a small reservoir at the head of the pipe line. The Guadalupe flume is three ft. wide by two ft. high and 6000 ft. long. Its grade is 0.20 per cent.

The San Juancito pipe line is made up of three different sizes of pipe. The first is 20 inch riveted pipe, and runs from an elevation at the water box of 1345 feet above the power plant, down to an elevation of 1054 feet, making a total length of 784 feet. At this point, there is a section of tapered pipe which changes from 20 to 17 inches. There are 708 feet of 17 inch pipe which runs down to an elevation of 788 feet. From this point on down to an elevation of 644 feet, there is 689 feet of 14 inch riveted pipe, and from the 644 foot elevation to zero elevation, at the power plant, there are 2347 feet of 14 inch lap welded pipe. This makes a total of 4528 feet of pipe line and a total head of

1355 feet when the water box is full. Where the pipe line enters the power house, it divides into two branches, one for each machine. There are three valves on each of these branches—first, the main valve; second, the by-pass valve; and third, the needle valve which controls the size of the jet that issues from the nozzle.

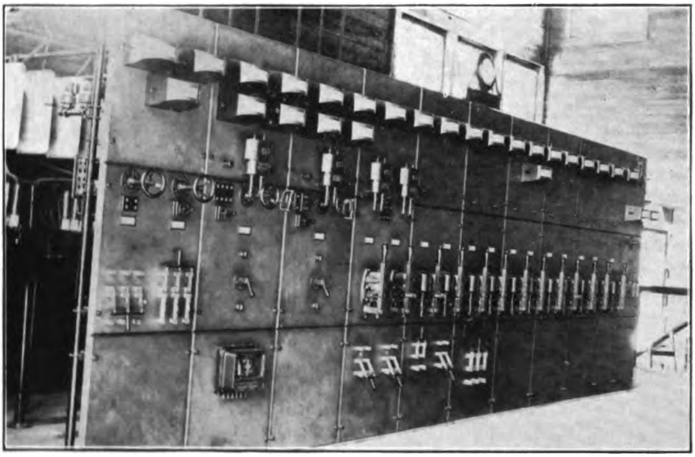
The pipe line for Guadalupe is all 20 inch riveted pipe and is 2500 feet long. When the Guadalupe water box is full, the static head at the plant is 486 feet. The pipe and valve arrangement inside the plant is the same as at San Juancito.



Pelton Water Wheels in Guadalupe Plant.

At the San Juancito plant, the equipment consists of two Pelton impulse water wheels, direct connected to Westinghouse 350 kv.a., three phase, sixty cycle, and 6600 volt alternators. The machines run at a speed of 600 r.p.m., which is controlled by means of a Pelton hydraulic governor. The principle of this governor is the deflecting of the water from the wheel whenever the speed tends to exceed the normal. This deflection is accomplished by means of an iron hood which swings in front of the nozzle and cuts off part of the water. A piston which is operated by oil under pressure, controls the movements of this hood. Whenever the speed tends to drop, the oil pressure causes the piston to move in such a manner that the hood will deflect less water. If the speed tends to increase the oil is forced into the other end of the cylinder and the piston moves the hood so that it will deflect more water. The oil is directed to the proper end of the cylinder by means of a distributing valve which is actuated by a centrifugal device. At the same time that the distributing valve admits oil to one end of the cylinder, it opens a port to let out the oil in the other end. A gear pump which maintains the oil pressure together with the centrifugal device, is driven by a belt from the Pelton shaft.

Since the deflecting hoods of each machine are mechanically connected so that they act together, the one governor serves for both machines. When the governor is for any reason out of service, the deflecting hoods are controlled by a hand wheel.



Switchboard in Rosario Substation.

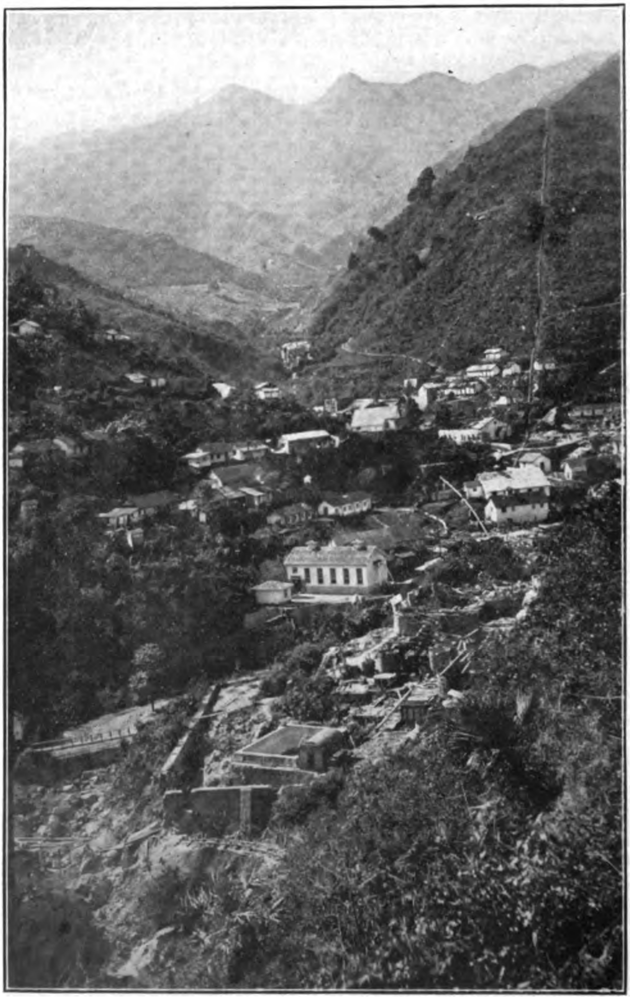
There are four panels on the switchboard—one exciter panel; two panels for the two alternators; and another panel with a power factor meter, an ammeter that reads total current for the station, and an automatic oil switch for the protection of the station apparatus. Besides these main panels, there is a small voltage regulator panel at one end, and a swinging bracket with voltmeter and synchroscope at the other end of the switchboard. At Guadalupe, the equipment is practically the same, except that the apparatus is General Electric instead of Westinghouse, and that there is no automatic oil switch panel on the switchboard. Each plant is protected from lightning and heavy surges by an aluminum cell lightning arrester used in connection with choke coils.

The two plants are operated in parallel. At the junction of the transmission lines there is a switch house with switches so arranged that either section of line may be cut out of service for repairs without interrupting the operation of the other plant. Either voltage regulator may be used alone, but the two regulators will not operate together because the line drop between each plant and the switch house is different except at a certain definite load for each plant. Consequently, except at this definite load, each regulator tends to give a different voltage at the switch house and they therefore work against each other. This difficulty could be remedied by adding a line drop compensating coil to each regulator. However, for the service here, one regulator is always sufficient to control the voltage, and for that reason the compensation for line drop has never been made.

Perhaps the greatest source of trouble in the operation of these plants is due to the interruption of the water supply to the pipe line. In the majority of cases, the reason for the water being held back, is that dirt, grass, leaves, etc., accumulate on the screens inside the water box at the entrance to the pipe line, thus effectually holding back the water so that instead of going through the screens, it overflows at the spillway. When the water is held back from the Guadalupe pipe line, it is only a matter of a very few minutes until the pipe line runs half dry, thus throwing the whole load suddenly on the other plant. In case of trouble at the San Juancito water box, however, the pipe is so long that almost the whole load may be carried for several minutes, thus giving plenty of time to notify the other plant and to call one of the sub-stations and have the load cut down until the water pressure returns to normal. At Guadalupe there is an automatic low pressure alarm which, when the pressure drops to the critical point, rings a bell that notifies the operator of the low pressure.

There are two sub-stations in the system. One is at Rosario, in the "Mill" building, and the other is in the air compressor station at Pena Blanca. At Rosario, the voltage is stepped down from 6600 to 2200. The stamps, which crush the ore, are driven by a Westinghouse 150 H. P. synchronous motor, with an additional 110 H. P. synchronous motor for emergency use. There is one clutch on the main shaft between the two motor pulleys and another clutch between both motor pulleys and the load. An induction motor, belted to the same section of main shaft as the emergency motor, is used for starting either motor.

The induction motor, however, drives both motors above synchronous speed. A special synchronizing device for starting the motors is employed, the following steps being required for starting: first, start the induction motor; then put field on the synchronous motor and raise its voltage to a predetermined value above line potential. It must be re-



San Juancito Plant. Pipe Line Shown in Background.

membered that the induction motor drives the synchronous motor above synchronous speed, and, if its voltage is above normal when the speed is above synchronism, then when the speed drops to synchronism, the voltage will at the same time drop to line potential. Having the synchronous motor running above synchronism and the voltage above normal, the induction motor oil switch is tripped out and the speed and voltage begin to drop. As soon as the induction motor circuit is opened, the control switch of the automatic synchronizer must be moved to the closing position, and when the speed and voltage of the synchronous motor decrease, so that they both reach normal at the same time, the automatic synchronizer closes a direct current circuit which closes the main switch. The synchronous motor is operated with a leading power factor of .60. This is done to raise the low lagging power factor of the line caused by the induction motor load.

At the Pena Blanca sub-station, the voltage is stepped down from 6600 to 440. The air compressors are driven by two 440 volt, 280 H. P. induction motors. There is also a motor generator set that supplies 250 volts, d. c., to operate the electric locomotives at the Pena Blanca level. There are in the mill, in the shops at Rosario and at Pena Blanca, and in the compressor station, 55 motors aggregating about 1600 H. P. In addition to these motors, there are six electric locomotives which haul the ore trains from the mine to the mill. Both sub-stations have aluminum cell lightning arresters, used in connection with choke coils, to protect the apparatus from lightning and heavy surges on the line.

Although the transmission line runs from an elevation of 3179 feet, at Guadalupe, to a 5895 foot elevation, at Pena Blanca, yet the line is entirely free from any noticeable atmospheric disturbances. However, in order to minimize such trouble, should it ever arise, there is a ground wire running on top of each pole from Guadalupe and San Juancito to the end of the line at Pena Blanca.

STREET LIGHTING IN CHICAGO

A. B. GATES, '09

During the year 1887, 105 direct current open arc lamps were installed in the down town district of Chicago. From year to year, lamps of the same type were added, until in 1898 there were 1,710 lamps operating. Up to this time, the lighting had been operated by a separate bureau of the fire department, but in 1898 the electrical department was created. The direct current arc lamps were supplied with current from Brush arc machines, belt connected to steam engines. An alternating current plant was added, and by 1908 there were 8,600 arc lamps operating on the streets of Chicago.

In the year 1908, the City of Chicago entered into a contract with the Sanitary District of Chicago, whereby the Sanitary District of Chicago was to supply the city with power. This contract made possible the much needed extensions in the lighting system. The steam engines were disconnected in the direct current stations and synchronous motors installed to drive the Brush arc machines. Transformers were installed in the alternating current stations and the steam engines and generators in these stations held for reserve capacity. Other alternating current stations were added and the lighting capacity was greatly enlarged. In 1910, there were 12,000 arc lamps in operation and during that year the City of Chicago entered into a second contract with the Sanitary District of Chicago, by which the Sanitary District agreed to operate and maintain the city lighting stations and to install 10,000 alternating current arc lamps of modern type, or their equivalent in other forms of lighting; also, to build the necessary stations (at least three in number), to take care of the new lighting, and to rehabilitate the old lighting system; and to replace the old direct current arc lamps and station equipment with modern alternating current arc lamps and station equipment. When this contract is completed, there will be on the streets of Chicago over 25,500 arc lamps or their equivalent. Over 75 per cent. of these will be lamps of modern type.

The arc lamp adopted, and of which there are about 10,000 now installed and operating on the streets of Chicago, is the "series alternating current long burning 10 ampere, flame arc lamp." These lamps are trimmed with white flaming carbons and adjusted to 465 watts at the terminals so as to have a maximum intensity of about 1,700 candle power at an angle of 25 degrees with the horizontal. They are being installed in the business and manufacturing districts, and in the residential districts where there are few trees. In most cases, the arc lamps are hung on one side of the street about 25 feet above the ground and average about 23 lamps to the mile. The same type of lamp is in general use on the boulevards, but here they are on both sides of the streets, staggered, and more closely spaced than on the business streets.

From 65 to 70 of these lamps are connected in series and from 30 to 60 circuits are operated out of one station. In most of the business districts, underground type of construction is being used. The cable is carried up through the iron pole and out through the hanger arm, all connections thus being concealed. In the outlying districts, aerial construction is used. In all the new districts, the lamps are provided with a raising and lowering device with an automatic circuit cut-out, so that the lamp may be lowered for inspection without disturbing the rest of the circuit and without danger to the repairman.

In the residential districts, where the trees would interfere with arc lamps which are necessarily hung a considerable distance above the street, four ampere 80 candle power, series, tungsten lamps are being installed. The lamps are mounted in a 14 inch spherical, opalescent globe about 11 feet from the ground, on a hollow cast iron pole. The pole is set in the parking about two feet from the curb. Iron armored cable is used for connecting these lamps. This cable is laid in the parking just inside the curb and buried about 1½ to 2 feet in the ground. The cable is run up through the hollow pole, so that all connections are concealed. These lamps are placed on both sides of the street and staggered so that there is a lamp to every 75 feet of street. About 230 lamps are connected in a circuit. There will be about 7,000 of these lamps installed.

An attempt has been made to divide the city into suitable districts so as to operate as many circuits as possible from one station, and in this way cut down the cost of operation. The power is distributed to these stations at 12,000 volts and is stepped down to 5,000 by 250 kv.a. transformers which are connected delta on the 12,000 volt side and star on the 5,000 volt side. The neutral of the low tension side is grounded and all banks in the station are normally operated in parallel. The arc and incandescent circuits are taken off of the live buses through automatic oil switches and induction type, constant current regulators, to the circuits, then back from the circuits, through air break disconnecting switches, to the neutral bus. This system is used in all the arc lighting stations in Chicago.

In districts where there is no electric lighting, a new type of single inverted mantle gas lamp is used. The lamps are about 12 feet above the ground and develop 50 candle power with a gas consumption of three cubic feet per hour. Gasoline mantle lamps were installed in such districts as were not supplied with gas mains. These lamps are very much like the gas lamps in appearance, except that the mantle is not of the inverted type. They develop 50 candle power through all glassware.

Besides the regular street lighting furnished by the city, there is a type of multiple cluster tungsten lighting supplied and maintained by the Chicago Edison Company and paid for by the merchants along the street. These clusters are placed a little inside the curb in accordance with a recent ordinance, which in the down-town district requires five lamps—one at the top of a 14 foot pole with the remaining four a little below, symmetrically arranged about it. In the outlying districts 12 foot poles are used. This lighting is turned off between 11 o'clock and midnight.

The elevation of the steam roads gave rise to a troublesome problem in the lighting of the subways or viaducts under these tracks. Some of these viaducts are nearly a half mile in length and must be lighted continuously. A standard of one 16 candle power lamp to every 400 square feet of street and sidewalk was adopted. Lamps are placed in the center of the ceiling above the sidewalk, with 20 foot spacing. The remaining lamps are then divided and spaced evenly along the curbs. In the first installations, the lamps were placed in enameled reflectors with the reflector throwing the lighting perpendicularly across the street, but it was found that by turning the reflector so as to throw the light across the street at an angle of 45 degrees with the direction of travel, a much better effect was obtained. By this scheme, the traffic ahead of the vehicle is illuminated and the reflector keeps the glare of the lamp out of the driver's eyes, as there is no light thrown opposite to the direction of travel, except that from the other driveway, and this causes little trouble, since the streets are comparatively wide and the center supports tend to cut off this light.

At the present time there are installed in the streets of Chicago,

30,000 10 ampere, alternating current, series, flame arc lamps,
1,300 9 ampere, direct current, open arc lamps,
4,700 6.6 ampere, alternating current, enclosed arc lamps,
3,500 4 ampere, alternating current, series, tungsten lamps,
12,000 inverted mantle, 50 candle power gas lamps,
6,500 upright mantle, 50 candle power gasoline lamps.

When the work covered by the present contract between the City of Chicago and the Sanitary District of Chicago is completed, there will be in operation in the streets and boulevards of Chicago over 50,000 lighting units.

The following approximate figures will give a fair idea of what it costs to operate and maintain the various types of lighting. These figures include interest and depreciation:

	Cost of lamp per year
10 ampere, flame, aerial type of construction	$55.00
10 ampere, flame, underground type of construction	73.00
4 ampere, series tungsten, underground type of construction	26.00
Gasoline, single mantle	30.00
Gas, single, inverted mantle	22.00

The cost per mile of lighting per year, including investment charges, is approximately as follows:

Flame lamps, underground type of construction	$1,700,00
Flame lamps, aerial type of construction	1,300.00
Series tungsten lamps	2,000.00
Inverted mantle single burner gas lamps	1,700.00

HYDROGRAPHIC AND TOPOGRAPHIC SURVEY OF THE WABASH RIVER AND VALLEY

E. B. NEWELL, '11

By Act of Congress in 1910, an investigation of the feasibility of improvement of the Wabash river from its mouth to Terre Haute, Indiana, was authorized. The investigation covered the possible methods of canalization, regularization, dredging, reservoirs, and combinations of these operations.

To secure the necessary data, a survey of the river and its valley subject to overflow at extreme high water was made under the direction of the U. S. District Engineer Office at Louisville, Ky., by Geo. H. Wolbrecht, U. S. Assistant Engineer. Preparations were started for the survey in the spring of 1911. The construction of the necessary equipment and requisition for instruments from Washington, D. C., covered a period of several months. In June, 1911, while these preparations were being made, a party was sent out to establish permanent gages at the following places: Terre Haute, Ind.; Darwin, Ill.; Riverton, Ind.; Vincennes, Ind.; St. Francisville, Ill.; Grayville, Ill., and Maunie, Ill. Permanent gages already existed at Grand Rapids Lock and Mt. Carmel, Ill. These gages were, in most cases, placed on bridge piers with a view to permanence. Observers who, in most cases were bridge watchmen, were appointed to keep a daily record of the stage. Elevation of the zero of these gages was referred to bench marks, the elevation of which was later determined by the precise level party.

The work of preparation was completed and the survey was organized at Terre Haute, Ind., in July, 1911. The floating plant necessary to carry on the survey consisted of two small house boats purchased and remodeled for the purpose of a survey party; one large quarter boat built for the purpose; one barge to carry provisions and property; one barge used as a drill boat; three especially designed gasoline launches; and six 24 foot yawls. The entire plant was designed to meet the conditions demanding strength and light draft.

In order to secure accurate results, it was decided to run a carefully measured base line and a line of precise levels, with separate bench marks for each, as a control for the survey. To make the river survey during the favorable low water season, it was decided to run the control and make the river survey on the first trip down the river, and then return and make the valley survey on the second trip. The control was run ahead of the topographic and hydrographis parties, so that computation necessary for the elevation and position of the permanent marks could be made.

The precise level and base line parties were organized as a unit and used the two smaller quarterboats; a supply boat; one gasoline launch; and three yawls as their floating plant. This party took the field July 20, 1911. Their organization at first consisted of one base line party and two precise level parties, but when it was found that the two precise level parties covered distance more rapidly than the base line party, one level party was converted into a low water discharge party and finally abandoned altogether. This party completed its work on the tenth of December, 1911, and was converted into a topographic and hydrographic party which assisted the second party to complete the river survey.

The base line consisted of a traverse, carefully taped with a standardized steel tape by two independent parties. The results were corrected for temperature and the two results had to check within the limit of one in 20,000 or the line was retaped. The courses were read by stadia as a check for large mistakes. The angles were read six times with a 10 in. transit-theodolite and the corrected azimuth was obtained by observation on Polaris and 51 Cephei at intervals of about 10 miles. Permanent bench marks were set at intervals of about every mile.

The latitude and longitude of the U. S. Coast and Geodetic Survey astronomical station at Vincennes was used as the basis of all horizontal measurements of the survey. A duplicate line of precise levels was run the entire length of the survey under the published instructions of the Mississippi River Commission with Kern levels borrowed from that office. Permanent bench marks were established at intervals of about five miles. Special care was taken in the setting of these marks in order to insure permanence and recovery. All elevations of the survey were finally referred to the 1907 adjusted value of the U. S. Coast and Geodetic

Survey bench mark Az at Vincennes, Ind., which is referred to mean sea level at Sandy Hook, N. J. References were made with the permanent marks of the U. S. Geological Survey at Terre Haute, Ind.; Shawneetown, Ill.; and also to permanent marks of the Ohio River Survey near the mouth of the Wabash river.

The topography was taken by transit and stadia in accordance with the published instructions of the Mississippi River Commission—the contour interval being five feet. All topography was plotted and sketched in the field as an aid to the final plotting. On the river survey, all features included between the low water line and main high banks or levees in close proximity of the river were taken. Special care was taken to locate caving banks and the extent of the bank in each case where cutting was in progress.

Probings consisted of driving a 25 foot rod to a depth of 20 feet below low water elevation to determine the character of the material of the river bed. Probings were taken at designated possible lock sites and on bars where there was less than four feet of water at low water stage. Three holes were driven on a range, one near each bank and one in the channel. Probings were taken on ranges about 450 feet apart, that is, alternately on the sounding range and midway between the next two sounding ranges. The exact location of the holes was not considered essential. The ordinary level party established elevations on water surface pegs, stadia stakes, base line bench marks, high water marks, and bottom chords of bridges.

Discharge measurements were taken with a Price current meter set at 0.6 depth where mean velocity was assumed. Low water measurements were taken at Terre Haute, Ind.; Vincennes, Ind.; Mt. Carmel, Ill.; New Harmony Ind., and below the mouth of Little Wabash river. Later, complete discharge curves were desired at Vincennes, Ind.; Mt. Carmel, Ill., and below the mouth of Litte Wabash river. These measurements were taken as the required stages became availabe. The current meter was rated in a pond near Vincennes and in the lock chamber at Grand Rapids lock and dam.

Considerable trouble was experienced in the moving of boats during the low water season, particularly on the river survey. The channel was so narrow, shallow, or tortuous that it was impossible to move the boats without much difficulty and loss of time. Although the maximum draft was only 15 inches, the boats were many times riding snags or grounded on bars. Many devices were resorted to. The capstain on the large boat proved useful, while Spanish windlasses were often necessary on the other boats. The gasoline launches were of no avail as their power was sufficient to steer only in the current, and make landings. In one extraordinary case, six yawls were sunk and filled with sand to form a dike. By this expedient, the boats were moved after having been hard aground for 20 hours. The problem of getting provisions from the nearest market when the boats were away from town proved troublesome. Only one week's supply could be kept in store during extremely warm weather. Boats in several cases were 30 miles from a market. Hauling overland was out of the question because of distance and expense. The gasoline launches were too slow to make the trip, and very few boats on the river could be induced to run during the low water season. Provisions were obtained by chartering privately owned gasoline boats, but not without much difficulty and cost.

The river survey was completed by the first of January, 1912, and the entire fleet was then towed back up the river. Owing to the freezing of the river while enroute, the fleet was forced into winter quarters at New Harmony, Ind. The winter proved very severe and the fleet was badly damaged by ice. While the boats were in winter quarters, four topographic parties were organized and work on the valley survey was begun in the vicinity of New Harmony. The boats were used as a base for a brief time but as the work became too far distant for the parties to return at night, they were subsisted by farm houses, or hotels in small towns in the vicinity of their work.

About 200 square miles of the valley immediately above and below New Harmony on both sides of the river were covered during two months of very rigorous winter weather, marked by heavy snows, and temperature much below zero. On March 11, 1912, the fleet was again started up the river and reached Terre Haute on March 21. High water at this period forced a discontinuance of field work for about three weeks. After this time, the work was resumed and the valley was surveyed on the second trip down the river. Wherever practicable, the work was laid out in one-half mile lines normal to the general direction of the stream. Each party was assigned one or more of these lines according to their lengths.

The large acreage of corn in the lower Wabash valley was a source of much trouble, delay and expense, and it was found almost impossible to cover the country thoroughly. The valley survey was completed on the tenth of September, 1912, after about 775 square miles had been traversed. The work was accomplished in 587 days, thus averaging 1.32 square miles per party working day. The gross cost, including all over head charges, was about 25 dollars per square mile.

Computations, consisting of the preliminary and the final computation of the base line and precise level line, together with the geographic position and elevation of all bench marks and topographic stakes, ratings, and results of discharge measurements were made in the field. Reduction of notes was begun and partly finished in the field and later completed in the district office. Final plotting of maps and profiles was done in the district office.

After the completion of the survey, a flood, surpassing all preceding floods in height and volume, occurred in April, 1913. A party was dispatched to determine its height shortly after the water receded. An accurate determination of its height was obtained about every five miles to determine the high water profile.

The Purdue Engineering Review

Vol. XIV, No. 7 PURDUE UNIVERSITY May, 1914

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FIELD BROADENS.

This number of *The Purdue Engineering Review* marks the first representation of the Chemical Engineering Society on the staff of the publication. All four engineering societies of the University now have an equal interest in this work. Though the School of Chemical Engineering is a comparatively new one, its growth has been rapid, so that it has quite a number of alumni engaged in fields of work which the *Engineering Review* has been unable to touch upon up until the present time.

COURSE IN SEMINAR.

It is generally recognized that the majority of technical school graduates are unable to express their views and opinions before an audience in an intelligible manner. It has been said jokingly that the graduate of the liberal arts school can express himself freely and fluently but he has nothing to say, while the engineer graduate has plenty to say but he is unable to talk. This is a queer state of affairs, but nevertheless it bears a semblance of the truth. To meet this situation, the School of Mechanical Engineering administers the subject seminar for the first semester of the senior year. Every student in this school is obliged to take the subject which is conducted in such a manner that he gains an extremely practical training in speaking before a critical audience. For the most part the subjects chosen, usually by the speaker himself, are of technical nature. Criticisms are given freely and it takes but a few appearances before a noticeable improvement is made. In the course of Gas Engines, the second semester's work devolves into a lecture course which is so outlined that every student taking the subject shall give an hour's talk on some phase of gas engine work, which shall require considerable amount of reading for preparation. Too much emphasis can not be laid upon such courses, for the engineer who is unable to express himself clearly and exactly will find himself at a great disadvantage in the business world. Great ideas that cannot be expressed in words are of no value. The sooner that the young engineer learns to take advantage of every opportunity to explain his technical knowledge in an intelligible manner, the quicker will he advance.

INTERNATIONAL ENGINEERING CONGRESS.

The committee in charge of the International Engineering Congress to be held in San Francisco during the Exposition announces that rapid progress is being made in working out the final program of papers. The first volume of the publication of the Congress will consist of a series of articles descriptive of the various technical features of the design and construction of the Panama canal. Colonel Goethals will handle one of the 22 topics as well as the introduction. This volume will constitute practically an official technical record of the gigantic feat which is just nearing completion and will be of interest not only to engineers but to laymen.

It has been announced that Colonel Goethals will preside as chairman of this Congress of engineers who will gather from all over the world.

NEW BULLETIN ON USE OF ELECTRIC FURNACE IN MAKING IRON AND STEEL

The investigations that the Bureau of Mines is making into the metallurgical industries, the appliance of electricity to various processes, and especially in the manufacture of iron and steel, is given attention in Bulletin 67, "Electric Furnaces for Making Iron and Steel," just issued by the Bureau. The investigations into electric furnaces for making iron were made by Dorsey A. Lyon, and electric furnaces for making steel by Robert M. Keeney. The bulletin gives a historical review of the development of electric furnaces for making iron and steel, and discusses the problems which remain to be solved in the use of electric furnaces for the smelting of iron ores and the production of pig iron at a profit on a commercial scale.

"Broadly speaking," Mr. Lyon declared, "it may be stated that the feasibility of smelting iron ores in an electric furnace depends upon the relative cost of either charcoal or coke and of electric power. In those electric-furnace iron plants that are operating at the present time only hydro-electric power is used. In general, there are few localities where the electric smelting of iron ores would be feasible with the electrical energy costing more than $0.20 to $0.30 per kilowatt-hour."

Mr. Keeney states that, "The cost of making steel in the electric furnace varies with local conditions. The cost of power does not enter so largely into the final cost as it does in some other electrometallurgical processes, especially the refining of molten steel. Plants are operating successfully under a power cost of one cent per kilowatt hour in localities where material can be obtained at the price common to other processes. Plants such as the one at Ugine, France, have been established in remote localities, where the cost of power is very low, 0.2 cent per kilowatt-hour, but the cost of material is high.

"For many years all high grade steels were manufactured by the crucible process, but since the advent of the electric furnace there has been a gradual adoption of that furnace for refining steel. For the complete refining of the highest grades of steel the use of the electric furnace is now thoroughly established in Europe. Any product that can be made by the crucible process can be made by the electric furnace, and in most cases with cheaper raw materials and at a lower cost. In the electric furnace complex alloy steels can be made with precision. The high temperatures attainable facilitate the reactions and alloys need not be used so largely for the purpose of removing gas. Very low carbon steels can be kept fluid at the high temperatures. Steels free from impurities and of great value for electrical apparatus can be made. With the electric furnace large castings can be made from one furnace, whereas in the crucible process steel from several crucibles must be used. For small castings, which require a very high grade metal free from slags and oxides, electrically refined steel is especially adapted. The electric furnace gives a metal of low or high carbon content as desired, hot enough to pour into thin molds and still free from slags and gases.

"There is now a tendency among consumers of rail and structural steel to require a higher grade steel at an increased price rather than steel of acid Bessemer or even of basic open hearth grade at a lower price. With the high cost of power that now prevails throughout the steel centers of the United States the electric furnace can not compete profitably with either the acid Bessemer or the basic open hearth process in manufacturing steel of like grade from pig iron. It is in combination with either of these processes that the electric furnace seems destined to be prominent in steel manufacture. The cost of superrefining in the electric furnace the molten steel from either of these processes, exclusive of the cost of the molten steel, varies from $1.50 to $2.25 per ton, depending on the cost of power and the impurities to be removed."

Department Notes

SCHOOL OF MECHANICAL ENGINEERING.

CHANGES IN INSTRUCTIONAL STAFF

During the last year a number of changes were made in the personnel of the instructional corps in the Mechanical Engineering department. J. S. Staudt, Assistant Professor in machine design, resigned to take up work with a consulting engineer. Mr. T. T. Eyre has been away on a leave of absence and at the present time is head of the Mechanic, Hydraulic, and Testing Material Laboratory of the Case School of Applied Science. Mr. R. W. Noland has been transferred from the Engine Laboratory to Machine Design. Mr. J. L. Snyder, M. M. E., Cornell University, has been appointed an assistant in the Engineering Laboratory. Mr. A. R. Nottingham is filling Mr. Eyre's place for one year as instructor in Mechanical Engineering. Professor A. W. Cole has become responsible for the administration of Thermodynamics. Professor H. S. Dickerson has taken charge of Steam and Gas Power as administered to the civil engineers.

GIFTS TO THE SCHOOL

A four cylinder automobile motor, donated by the Nordyke, Marmon Company, manufacturers of the Marmon automobile, has been set up in the gas engine laboratory, and is being used in thesis work. The American Foundries Company has given a complete freight car truck to be used in experimental work. Numerous other valuable material has been donated by a large number of firms, such as carburetors, samples of steam turbine blading, bars of spring steel, jacks, separator models, oil samples, catalogue and filing case, and a variety of data in the form of drawings, blueprints, and tabulated results.

NEW EQUIPMENT

The school has acquired a small amount of new apparatus within the past year. An electric pyrometer complete with thermo couples for high temperatures has been bought. At the present time, a belt testing apparatus is being constructed in the Purdue shops, which will contain some novel features. A flue gas analysis outfit has been obtained and has found much use in the boiler test in the power house. Water weights for automatically weighing and recording weights of water has been added to the equipment.

RESEARCH WORK

Quite a number of problems connected with the automobile is being investigated at the present time. An attempt is being made to determine the road and wind resistances. Tests are being run on kerosene carburetors. A study of the effect of mufflers on the power and efficiency of automobile motors has been in progress for the last two years. A series of comparative carburetor tests is being conducted this spring. Work leading to the determination of the power and fuel consumption of electric lighting and starting systems has been started. The study of lubricating oils is being continued. A number of interesting problems are still under investigation, such as the fixing of the tar forming temperatures of American coals; the adapting of a suction gas producer to bituminous coals; and the determination of the coking qualities of American coals.

SCHOOL OF ELECTRICAL ENGINEERING

NEW HIGH POTENTIAL LABORATORY

A new laboratory for high potential research has been installed during the past year in the room previously used for laboratory calculations. This laboratory is now equipped with the 300,000 volt transformer constructed by students as thesis work in 1909 which is connected with high tension tubular bus bars running the entire length of the room on suspension insulators. These bus bars may be connected through wall bushings to the experimental high tension transmission line or to other high tension apparatus to be tested in the laboratory. Seniors this year are constructing standard sphere and needle spark gaps for the measurement of high potentials and a large parallel plate condenser consisting of ten plates of galvanized iron each 4 feet by 5 feet has also been constructed for the purpose of investigating the electrostatic field at very high voltages. Research work in connection with corona loss on the experimental high tension line is being continued this year and another study of the comparison of the actual and theoretical interference between high tension line and telephone line is also being undertaken.

CALIBRATION LABORATORY

The room previously occupied by the high potential laboratory has been very completely equipped for calibration work. This has been particularly necessary because of the standardization work which is to be done in the near future for the Public Utility Commission.

NEW COURSE IN PUBLIC CORPORATION MANAGEMENT AND REGULATION

Owing to the demand for technical graduates for commercial and executive positions a new elective course covering the organization, management and regulation of public utilities will be established during the coming year. This course will give the students some idea of the financial and accounting problems involved in the management of public utility corporations and their appraisal and regulation as carried on by the various state public service commissions.

PERSONNEL

Professor Alfred Still, the prominent English engineer who held a tentative position on the staff during the second semester of last year, has now joined the permanent staff of the School of Electrical Engineering as assistant professor. Prof. D. D. Ewing, formerly head professor of the electrical and mechanical departments at Ohio Northern University, who was engaged in graduate work here last year has also been made assistant professor on the permanent staff. Mr. R. V. Achatz, of the 1908 class who has since graduation been engaged with the A. T. & T. Co., in operating and appraisal work as well as with the B. J. Arnold Co., of Chicago, is now instructor in telephone engineering and assistant in the general laboratory work. Mr. J. B. Sheadel, of the 1911 class, is acting as assistant in the laboratory during the present year.

SCHOOL OF CIVIL ENGINEERING

ENGINEERING CAMP

A new course in civil engineering is to be put in operation with the present sophomores, who will attend an engineering camp from June 6th until July 4th. The state forest reserve, in Clarke County, Indiana, about twenty miles north of Louisville, has been chosen for the camp on account of its great variety of topographical conditions. The tract comprises 4,000 acres and is nearly five miles in length. Through it runs a chain of hills, with knobs elevated about 500 feet above the valleys. The sleeping headquarters are situated on one of these knobs that commands a wide and beautiful view over the valley of the Ohio river. The students will lead a camp life in all respects. The work will comprise geodetic and astronomical surveys, topographical, railway and highway surveying.

SERVICE TO STATE

The school exercises an increasing activity in the state and in municipalities. It is coming to occupy the same position in the state with respect to the problems of water supply, sewage disposal, road and bridge construction, and drainage, that the school of agriculture does to the problems of agriculture. The second engineering conference of county officials was held at the school this year, and resulted in the passage of a resolution calling upon the state to establish a good roads school at Purdue University for the newly created road officials, to last ten days each year.

CHANGES IN COURSE

A special course in highway engineering has been established in the senior year, and it is expected that an assistant professorship of highway engineering will be established. In this way the school will be able to comply with the increasing number of requests for cooperation and extension teaching for highway engineering. The establishment of the engineering camp has made possible the increasing work in hydraulic engineering. Fundamental hydraulics and hydraulic laboratory will be taken by the junior civil engineers, and a larger course in hydraulic motors will occupy the first semester of the senior year.

A course of general lectures upon the history of distinguished engineers and descriptions of notable engineering constructions will be given to the juniors in the first semester.

SPECIAL RESEARCH

In the hydraulic laboratory the research work on the frictional resistance of sand-carrying water has been completed, and is being prepared for publication. At the request of the President of the American Waterworks Association tests are being made of the strength and failure of lead pipe and the brass fittings usually employed in house connections to water mains. The pipe varies from ¾ of an inch to 2 inches in diameter and the various weights of pipe are all included. In the laboratory for testing materials the investigation of reinforcing bars rerolled from steel rails was carried on for the American Society for Testing Materials, and reported to the association. Professor Sackett of the hydraulic department has been active in the flood protection work of the state. Professors Hatt and Smith have served on the board of engineers for the construction of the new Main Street bridge. Professor Sackett has been appointed a member of the Board of Public Works of the City of Lafayette. Professors Garman and Case have left the University to take on new responsibilities. Professor Garman becomes chief engineer of the Public Utilities Commission, and Professor Case becomes Professor of Sanitary Engineering at Pittsburgh University.

SCHOOL OF CHEMICAL ENGINEERING

DESCRIPTION OF COURSE

The Purdue catalogue of 1906-07 contained the first announcement of a course in chemical engineering, and the first graduate from this course received his diploma in 1910. The School of Chemical Engineering was established in 1911 and now has an enrollment of 139, a graduating class of 13, and 35 alumni. The school was established to meet a demand which has resulted from the increasing application of chemical principles to engineering problems and manufacturing processes. The rapid development of the strictly chemical industries, as well as recognition by engineers of the importance of the chemical aspects of their particular problems, has emphasized the demand for men so trained as to combine the functions of both chemist and engineer. To meet these requirements, a course of study is necessary, which includes, with mathematics, physics, and their applications in engineering, a thorough knowledge of chemistry. The course as laid down at this institution, is a general course in engineering and chemistry, with no attempt to specialize in any direction. The chemical engineer, therefore, occupies a middle ground between the engineer and the chemist, with the advantage over the former of chemical training and over the latter of a knowledge of engineering. His training is a preparation for such positions as chemist, engineer, or manager in those industries which involve the application of chemical and engineering principles, or for positions along engineering lines where a knowledge of chemistry is necessary. In the development of the plan of study of this school probably the most noteworthy point brought out is the advantage arising from the general nature of the course, resulting in a broadening of the young engineer's sphere of activities and increasing his opportunities.

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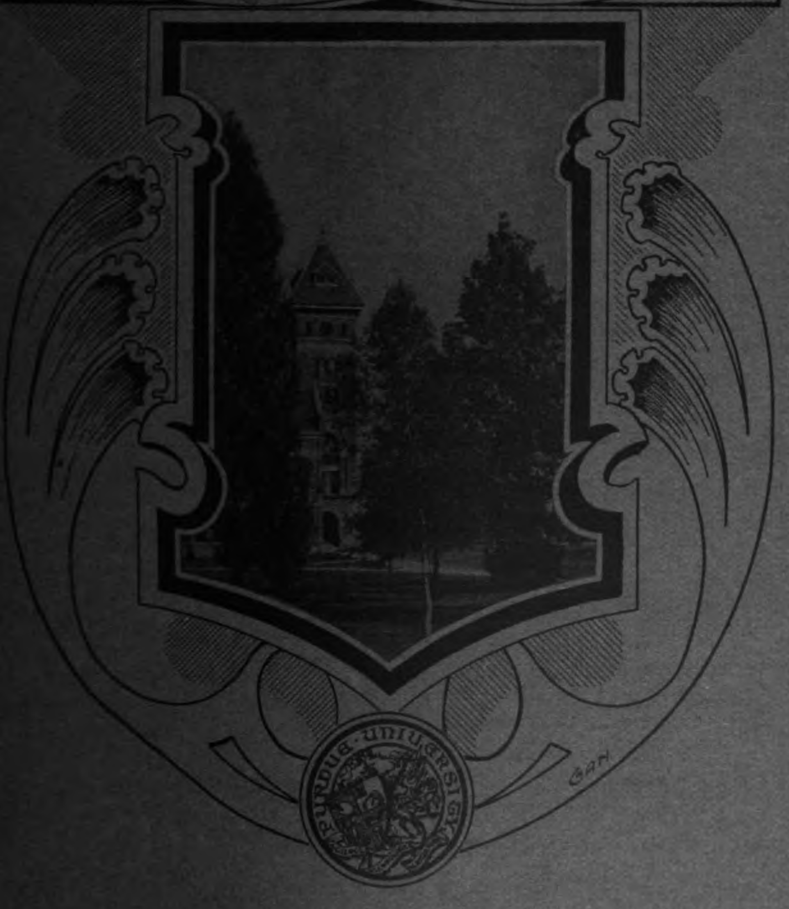

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PURDUE ENGINEERING REVIEW

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FLOOD PROTECTION IN INDIANA*

By W. K. Hatt,

Professor of Civil Engineering

The appointment of the Indiana Flood Commission was the direct result of the flood of March, 1913, in which 467 lives were lost and over $160,000,000.00 of property destroyed in the United States. The memory of this catastrophe is still fresh in the minds of the people of Indiana, in which State 39 lives were lost, and over $25,000,000.00 of property destroyed.

The total loss in the flood of March, 1913, can never be known. The interruption of transportation and of business, the destruction to farm lands by cutting of banks of rivers and covering of bottom lands with gravel, the loss of productive capacity of manufacturing plants, and the sickness following exposure, are not susceptible of exact computation.

Professor Beede of Indiana University reports a total damage of approximately one-half million dollars, in seven counties in the lower White River basin, in which also nearly eight thousand acres of agricultural land were denuded of soil and some sixteen thousand acres of river bottoms were covered with sand and silt. He estimates the loss to agricultural land in this region as nearly $250,000.00.

Part of the damage to country roads and bridges reported by the county auditors was over $3,000,000.00. Other tangible losses that have been determined are shown in Table 1. It is probable that other losses during the flood of March, 1913, in Indiana will bring the total losses to more than $25,000,000.00.

Indeed the catastrophe was so general over the Ohio Valley that it excited the sympathy and support of the entire nation. The Governor of the State of Indiana received $141,088.96 in subscriptions for the relief of flood sufferers in this State.

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*Condensed from Bulletin No. 4, Bureau of Legislative Information; written by Professor Hatt.

TABLE NO. I.

PART OF DAMAGES SUSTAINED IN INDIANA IN THE FLOOD OF MARCH, 1913

1.	**County Highways and Bridges**	**$2,825,240.00**
2.	**Railroads—Steam**	**5,299,810.00**
3.	**Electric Railways**	**788,000.00**
4.	**Buildings and Personal Property**	**8,104,250.00**
5.	**Telephone and Telegraph**	**200,000.00**
6.	**Crops**	**735,700.00**
7.	**Live Stock**	**149,380.00**
8.	**Farm Lands (part of White river only)**	**247,500.00**
9.	**Suspension of Business**	**582,000.00**
	Total	**$18,949,390.00**

Counties not included in (1)
Cass,
Floyd,
Clinton,
Miami,
Fayette,
Sullivan.

Railroads not included in (2).
Central Indiana R. R.
Chicago and Wabash R. R.
Cin. Ham. and Dayton R. R.
Toledo, Peoria and West'n R. R.
Toledo, St. L. and West'n R. R.

Electric lines not included in (3).
Marion and Bluffton Trac. Co.
Bluffton, Geneva and Celina Trac. Co.
Central Indiana Lighting Co.
Indianapolis Street Ry. Co.
Louisville and Southern Trac. Co.
Louisville and Northern Ry. and Light Co.
Vincennes Trac. Co.
Washington Street Ry. Co.

(5) Includes Indianapolis Telephone Co. and Central Union Telephone Co.

Counties in Flood Districts not included in (4), (6), (7) and (9).

Adams,
Blackford,
Cass,
Clark,
Clay,
Clinton,
Fayette,
Floyd,
Fountain,
Franklin,
Gibson,
Grant,
Greene,
Harrison,
Howard,
Huntington,
Jay,
Jefferson,
Ohio,
Parke,
Perry,
Putnam,
Randolph,
Ripley,
Scott,
Sullivan,
Switzerland,
Tippecanoe,
Vanderburg
Vermillion,
Vigo,
Wabash,
Warrick,
Wells,
White,
Whitley.

(8) Includes loss only in 230 miles of East and West Forks of the White River through Morgan, Owen, Greene, Daviess, Knox, Jackson, Lawrence and Martin Counties.

FORMER FLOODS IN INDIANA

Floods have occured in Indiana as far back as records are obtainable. In the early days, before levees had been raised above high water, and before cities had been built in the bottoms, the losses were small, and people did not have to pass over the river until the flood waters subsided.

In recent years the effects of similar floods have become more serious, and the problem has become acute. It has been made so by the inevitable encroachments on the flood plains and bottoms which were formerly given up to the rivers during floods, while at the same time, channels have not been improved in proportion to the encroachment.

Serious floods may occur at any time throughout the year, but they usually happen between December and April. January, February, and March are the months when the combination of rainfall and surface conditions produce the worst effects.

The following floods have been state wide in Indiana:

January, 1847—Rainfall.
June, 1857—
September, 1866—Series of heavy thunderstorms.
August, 1875—Heavy rains following wet summer.
February, 1883—High monthly precipitation with thaw.
March, 1897—Series of excessive rains.
March, 1904—Series of storms.
February, 1908—Moderate rain with thaw.
October, 1910—Single protracted storm.
January, 1913—Single protracted storm.
March, 1913—Two protracted storms, practically one.

CHARACTERISTICS OF FLOODS

A heavy storm, shedding long continued rain, sweeps up the Ohio Valley, and finds the ground frozen or covered with snow, the subsoil saturated and the channels already charged with water, so that the greater part of this rainfall runs off through the streams.

The tributaries may all be discharging and attempting to find outlet at the same time, through the main channel, in which people have been dumping refuse, constructing levees and buildings that add to the height of flood waters.

The meteorological conditions attending serious floods are made clear in Diagrams 1 to 4. A storm starts in the southwest and follows up a trough of low pressure between

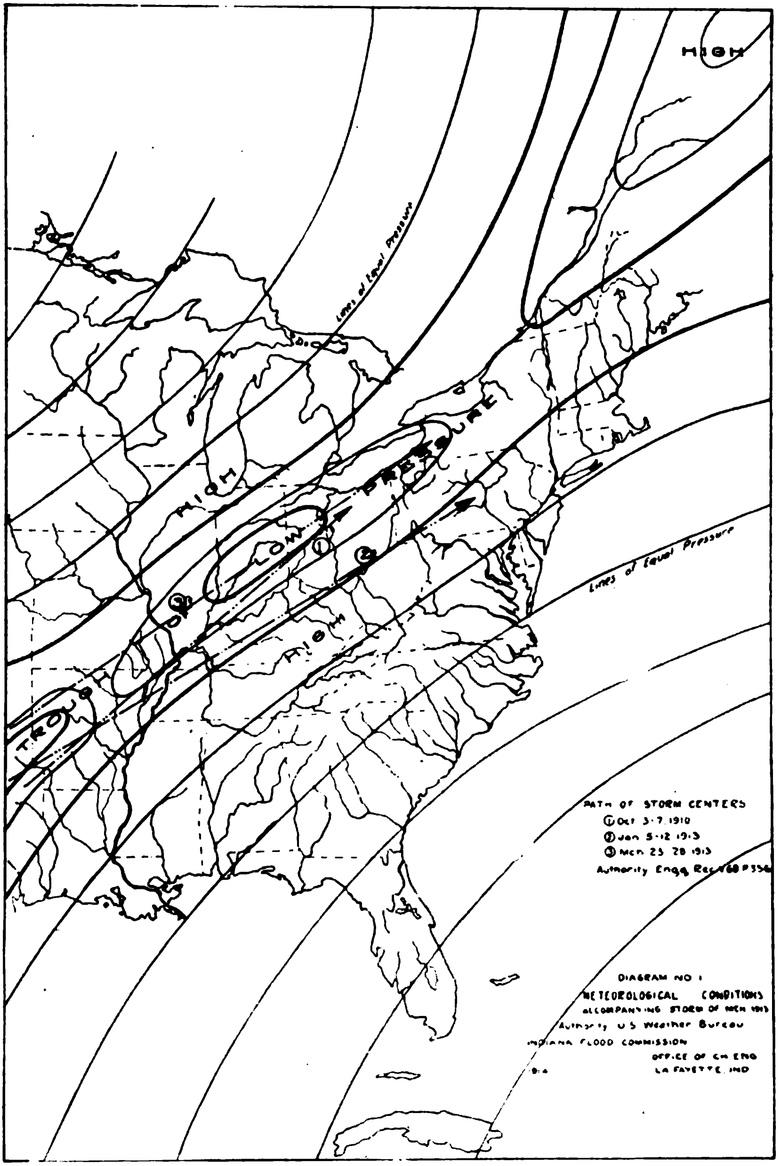
HIGH
Lines of Equal Pressure
HIGH
LOW
PRESSURE
TROUGH OF LOW
HIGH
①
②
③
Lines of Equal Pressure
PATH OF STORM CENTERS
① Oct 3-7 1910
② Jan 5-12 1913
③ Mch 23 28 1913
Authority Engg Rec V68 P356
DIAGRAM NO 1
METEOROLOGICAL CONDITIONS
ACCOMPANYING STORM OF MCH 1913
Authority U S Weather Bureau
INDIANA FLOOD COMMISSION
OFFICE OF CH ENG
LA FAYETTE, IND
1914

Diagram No. 1.

two high pressure areas on either side of the Ohio Valley. Sometimes a second storm follows up the first immediately, and it is a further burden upon the overtaxed channels. (See Diagram 1.)

Records are available of three notable past storms, (shown in Diagrams 2 to 4) that of October, 1910; that of January, 1913; and that of March, 1913; characterized by a heavy intensity of rainfall over large areas, the two latter coming at the time of year when very little of the rainfall was absorbed in the ground.

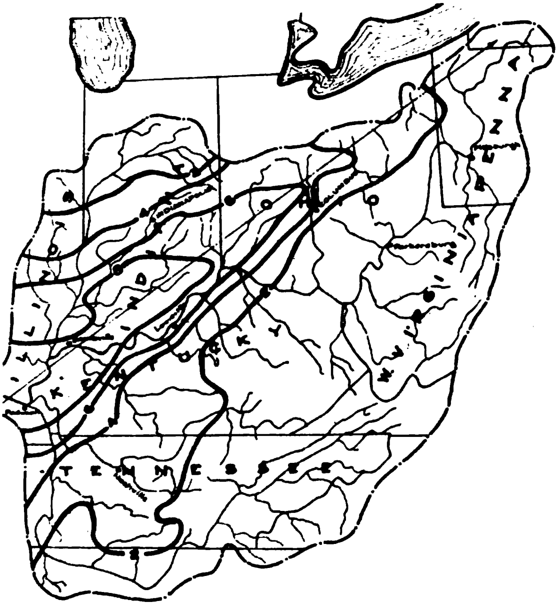

Diagram No. 2.

As we shall see later, storms such as these are a measure of the amount of river discharge that flood protection works must carry.

Diagram 1 shows the paths taken by these three excessive storms. The northern portions of Indiana lie outside the track of these storms. For example, the Eel River and the Tippecanoe River are not likely to receive as heavy rainfall as the East and West Forks of the White River, because the latter lie in the path of these severe storms.

Diagrams 5 and 6 are drawn to show the inches of rainfall that fell at various localities affected by the storm. It is plain that large areas receive a less average rainfall than small areas. For instance, in Diagram 5, we find that in January, 1913, an area of 500 square miles had a rainfall in excess of eleven inches; an area of 2,500 square miles had a rainfall in excess of ten inches; and an area of 14,500 square miles had a rainfall in excess of eight inches. From

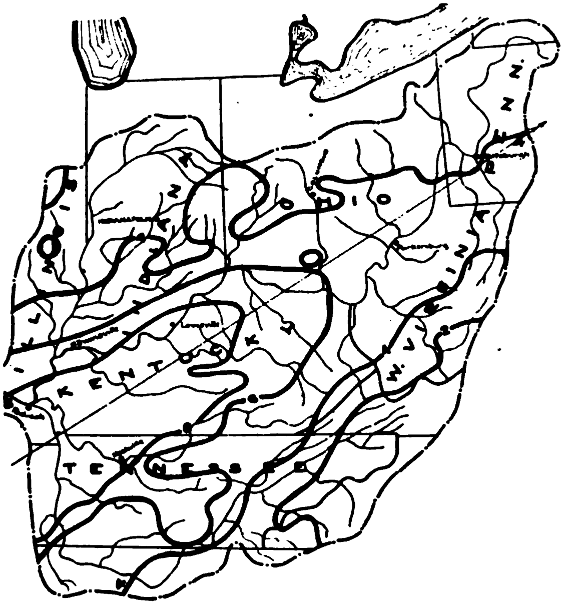

Diagram No. 3

a study of the three storms, Diagram 7 has been prepared to show the relation between an area of given size in a watershed, that lies in the path of these storms, and the amount of rain that may reasonably be expected on this area.

Possible Future Storms

The storm of March, 1913, was not as heavy as either that of January, 1913, or that of October, 1910. Of course a combination of the storm of January and a snow-covered surface is possible, and would have caused a flood greatly in excess of that of March. It is fortunate that these storms sweep up the Ohio Valley instead of down, because the latter storm would tax the channel more severely than the former.

Of course, small areas in any part of the State may receive a heavy local rainfall, at any time of the year, and bridge openings must provide for this rainfall. For instance, in the Muskingum Valley an unprecedented rain-storm occurred in July, 1913, following the flood of March, 1913, causing flood heights higher than those of the previous storms. At one station a rainfall of 7.17 inches was recorded for a period less than nine hours.

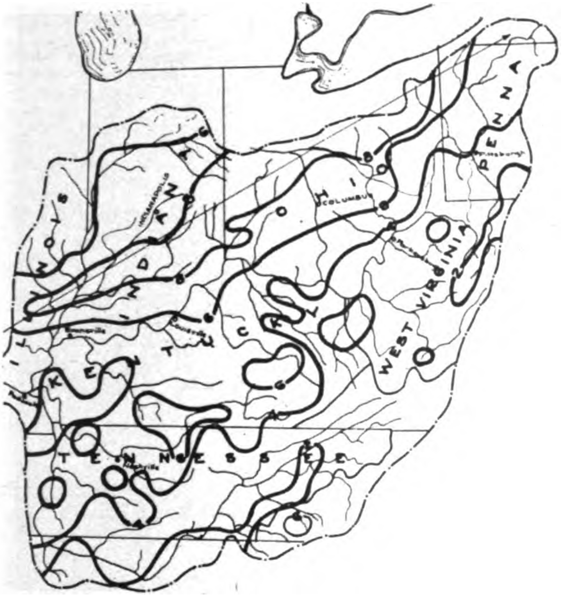

Diagram No. 4

But we are now speaking of storms that cause widespread floods over an entire watershed, and trying to estimate what rainfall we should provide for in improved channels and under bridges in plans for flood protection works.

A simple method is to specify that these works shall carry the rainfall of March, 1913, which caused the greatest flood on record, and then add to this an arbitrary increase of one-third in the White River and a less amount in the more northerly watersheds further removed from the path of extraordinary storms.

Diagram 6 shows (Lines a) the actual rainfall that occurred in the Wabash Valley and the two forks of the White River in March, 1913, and also (Lines b) the rainfall that would have fallen if the March storm had been increased by a factor of one-third on the White River, and a factor of one-fourth on the Wabash River. This increased rainfall on the East Fork of the White River and the lower Wabash River is nearly the same as that which would have occurred if the storm of January, 1913, had followed a path 75 miles farther north.

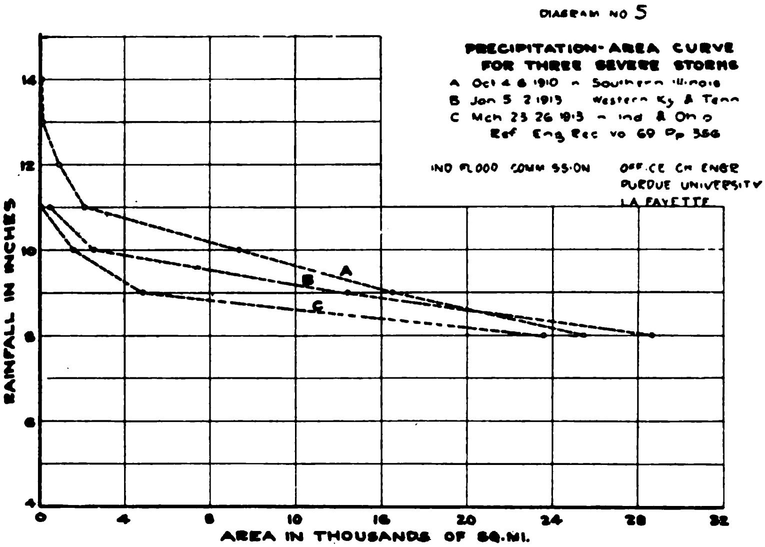

Diagram No. 5

Of course if such a storm as that of October, 1910, were arbitrarily shifted to a path over the headwaters of the Wabash, extraordinary conditions would be found. As a matter of fact, however, the centers of these storms causing severe floods in Indiana do not pass this far north. It would be unreasonable to predict a rainfall intensity in northern Indiana and impose a factor of safety against future contingencies, as high as equal areas receive in the White River Valley.

CONCLUSION AS TO RAINFALL

In general, then, we may reasonably require that the constructions for flood protection works on the Wabash and the White Rivers should provide for the rainfall shown by the lines in Diagram 7.

PERIODICITY OF RAINFALL

A curious relation between the amounts of rainfall through cycles of years is evident from Diagram 8 which shows the distribution of yearly rainfall since 1830. The cycle of 34 years from a period of excessive rainfall to deficient rainfall is evident in the region around Cincinnati. On the basis of this Diagram, some are inclined to predict heavy floods in the near future. They say that we have been passing through a series of years of deficient rainfall in conjunction with increased farm drainage and growing encroachments upon stream channels, and that excessive floods are indicated for the near future.

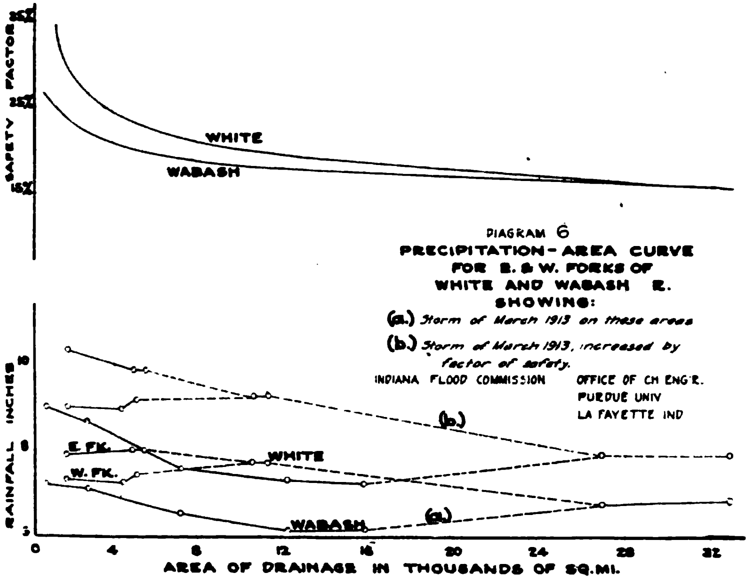

Diagram No. 6

Inasmuch as the great floods occur in the months of January to March, inclusive, similar periodicity Diagrams have been drawn for these months, (See Diagram 9) and the close connection between the excessive rainfall and severe floods is evident.

These Diagrams (8 and 9) show progressive averages, that is to say, to obtain the rainfall for any year, the rainfall of the previous year and succeeding year are averaged along with the rainfall of the year in question. The latter is given double the weight of the others in this average.

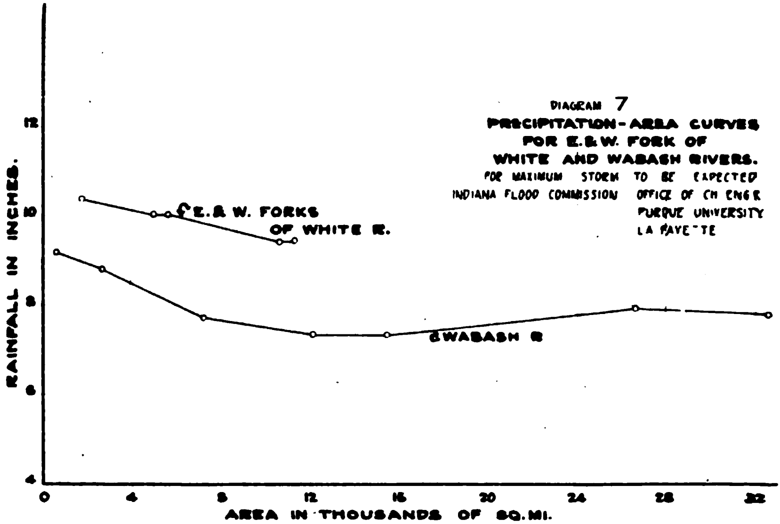

Diagram No. 7

RAINFALL AND STREAM DISCHARGE

How much of this rainfall will discharge in the rivers? Only a part of the rain that falls on the upper reaches of a watershed ordinarily runs by a city below. Great floods occur when the greater part of the rainfall runs off in the streams during the extraordinary storms.

Part of the rainfall is held back for a time in porous subsoil, in swamps, and in the ground surface, especially in forest cover, and is let out gradually.

Part of the water also disappears through evaporation and is used by vegetation.

For instance, in the former days before land was drained for agriculture, the heavy rains of the winter and spring were held back in the swamps and other natural detaining agencies, until near mid-summer.

There was higher water in the streams throughout the summer than at present, and the ordinary workings of the river were more even.

There is no doubt but that, because of the cutting down of the forests and the draining of the swamps, and the construction of large drainage systems for farm lands, the rain now runs more rapidly to the watercourses, and the height between ordinary high and low water is greater. These new conditions must cause more frequent floodings of our river bottoms.

But these tremendous floods like March, 1913, are due to severe storms that send rain down upon the surface when the soil is already as full as a wet sponge, or frozen, or when there is snow on the ground. Even if the swamps and forests were in existence, they would have had no further capacity left to take this heavy rainfall. . It would have run quickly into the streams as it does now.

Then, too, in early times, the bottoms of the rivers were grown up in thick forests which offered great resistance to the free flow of flood waters over the bottoms outside of the river channel.

Those who have given close study to the matter are not able to find evidence that the flood heights during these extreme floods are higher than flood heights in early days, except in the cities and other localities where the embankments, levees, buildings and bridges have made local obstructions that dam up the waters, and create a head of back water.

One serious problem in Indiana at present is the control of future obstructions to the free flow of flood water in our streams, and to remove present obstructions that will interfere with the building of flood protection works by our cities.

DETERMINATION OF RIVER DISCHARGE

The part of the rainfall that runs off into the streams, that is, the "runoff,' is expressed as river discharge. The shape of the watershed whether long and narrow, or short and wide, and the character of the surface, whether rocky or with deep gravel sub-soil, and the convergence of the side tributaries and the steepness of the watershed, each has its own particular effect on the rate at which the runoff reaches the river channel.

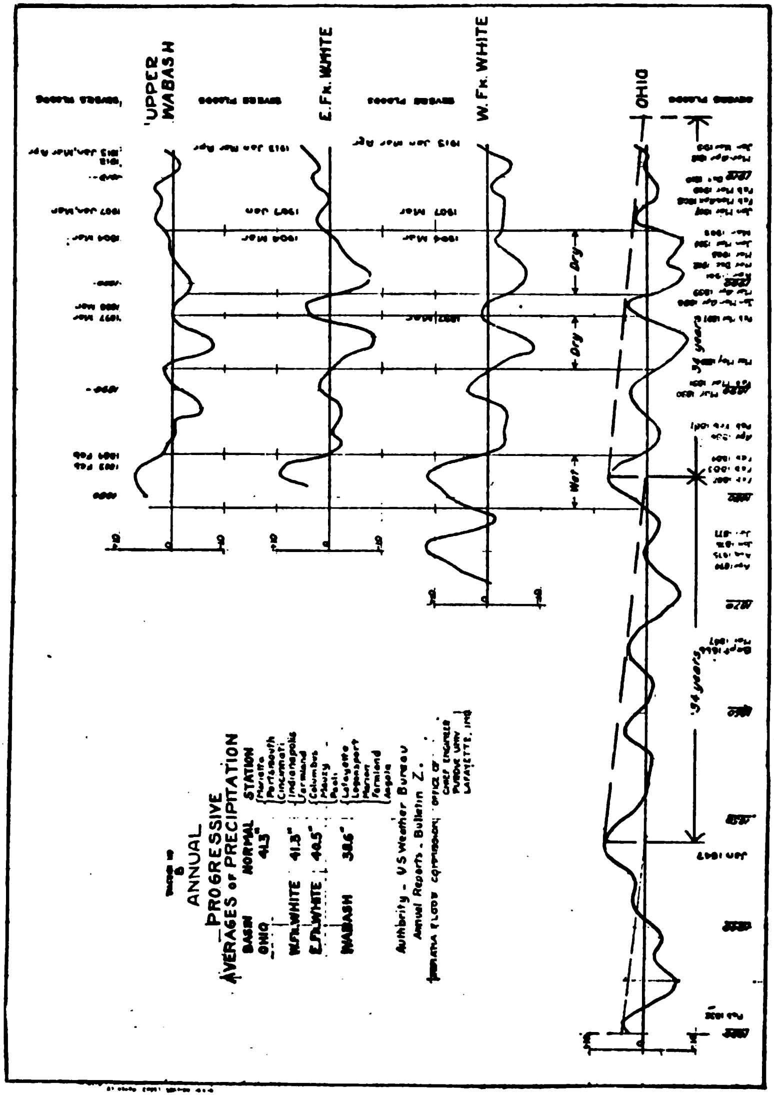
ANNUAL
PROGRESSIVE
AVERAGES of PRECIPITATION
BASIN
NORMAL
STATION
OHIO
41.3"
Marietta
Portsmouth
Cincinnati
W.FK.WHITE
41.3"
Indianapolis
Farmland
E.FK.WHITE
40.5"
Columbus
Mauzy
Paoli
WABASH
38.6"
Lafayette
Logansport
Marion
Farmland
Angola
Authbrity - U S Weather Bureau
Annual Reports - Bulletin Z.
INDIANA FLOOD COMMISSION; OFFICE OF CHIEF ENGINEER PURDUE UNIV LAFAYETTE, IND
UPPER WABASH
E.FK.WHITE
W.FK.WHITE
OHIO
SEVERE FLOODS
Wet
Dry
Dry
34 years
34 years
+10
0
-10
1913 Jan Mar Apr
1907 Jan Mar
1904 Mar
1897 Mar
1883 Feb
1884 Feb
Jan 1847
Feb 1832

Diagram No. 8

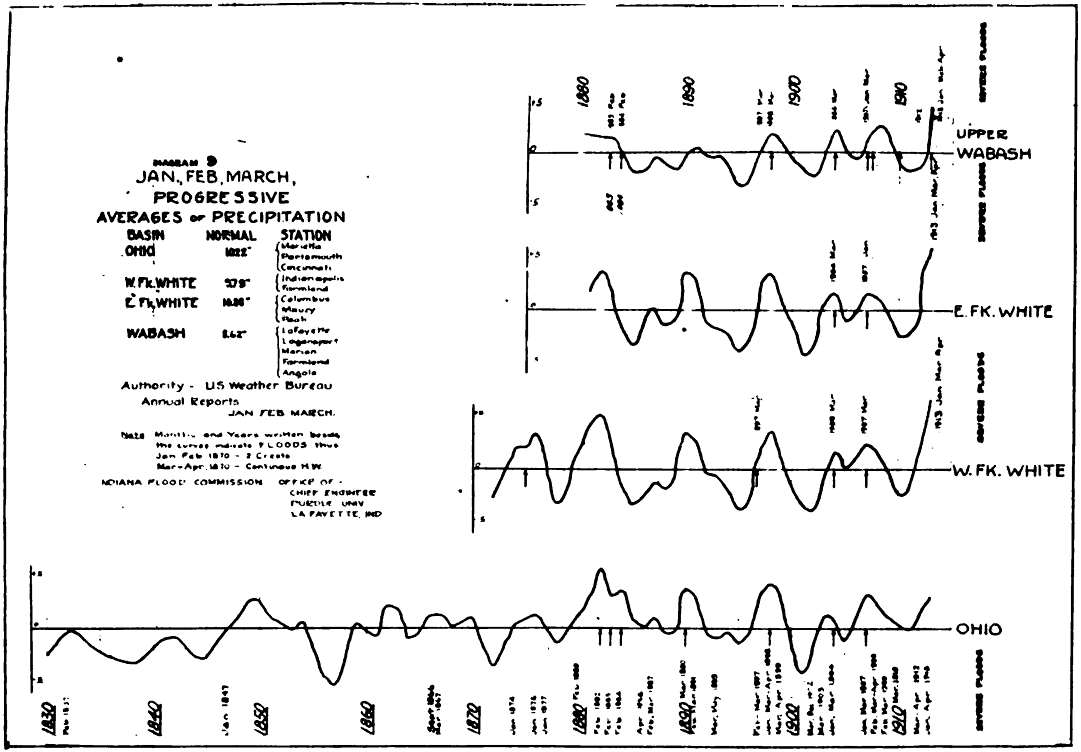
DIAGRAM 9
JAN., FEB., MARCH,
PROGRESSIVE
AVERAGES OF PRECIPITATION
BASIN NORMAL STATION
OHIO 10.22" Marietta, Portsmouth, Cincinnati
W. FK. WHITE 9.78" Indianapolis, Farmland
E. FK. WHITE 10.86" Columbus, Maury, Rush
WABASH 8.62" LaFayette, Logansport, Marion, Farmland, Angola
Authority - US Weather Bureau
Annual Reports
JAN FEB MARCH.
Note Months and Years written beside the curves indicate FLOODS thus
Jan Feb 1870 - 2 Crests
Mar-Apr. 1870 - Continuous H.W.
INDIANA FLOOD COMMISSION OFFICE OF - CHIEF ENGINEER PURDUE UNIV LA FAYETTE, IND
UPPER WABASH
E. FK. WHITE
W. FK. WHITE
OHIO
SEVERE FLOODS
+5
0
-5
1830
1840
1850
1860
1870
1880
1890
1900
1910
1913 Jan Mar Apr

Diagram No. 9

A long narrow watershed will not deliver rainfall as quickly to a point in the channel below as will a short and compact watershed.

The difficult problem is to compute the river discharge at any city arising from the rainfall on the watershed above.

Certain formulas have been proposed by which the river discharge may be computed. For instance, Mr. W. E. Fuller's formula, (Proc. Am. Soc. Civil Eng., Vol. 39, p. 1012) is

$$Q = CA^{0.8}$$

where Q is the average yearly flood, in cubic feet per second; C is the coefficient which is constant for the river at the point of observation; A is the catchment area of river in square miles.

Mr. Fuller remarks that the largest flood occurring in one hundred years will be 2.6 times the average yearly flood. This subject is now under lively discussion by engineers and other formulas are proposed, but all of these must depend upon the measurements of river discharge, which are lacking for conditions in Indiana.

The only certain method is to actually measure, by well known methods and tried instruments, the discharge of our rivers through a long term of years. Many States have done this in co-operation with the United States Geological Survey. Then the engineer will know the number of cubic feet per second of river-discharge for which flood protection works must be designed.

But we have made so little progress in scientific study of our streams that we are seriously handicapped in studies for flood protection.

Certainly one important effort that the State of Indiana must exert in the future is to provide for these streams gagings through a co-operative agreement with the United States Geological Survey, which has trained men and the instrumental equipment to perform this work efficiently.

These stream gagings would, however, require a long term of years for their completion.

Meanwhile many of our cities are in increasing danger from floods. In some cities the situation is acute and the people can not wait for a complete determination of scientific data before planning flood protection works.

For immediate purposes and in the absence of full information, the following method of solving the problem will be found useful and reasonably satisfactory.

Briefly, the method consists in finding the river discharge at selected points, the rainfall in the valleys above

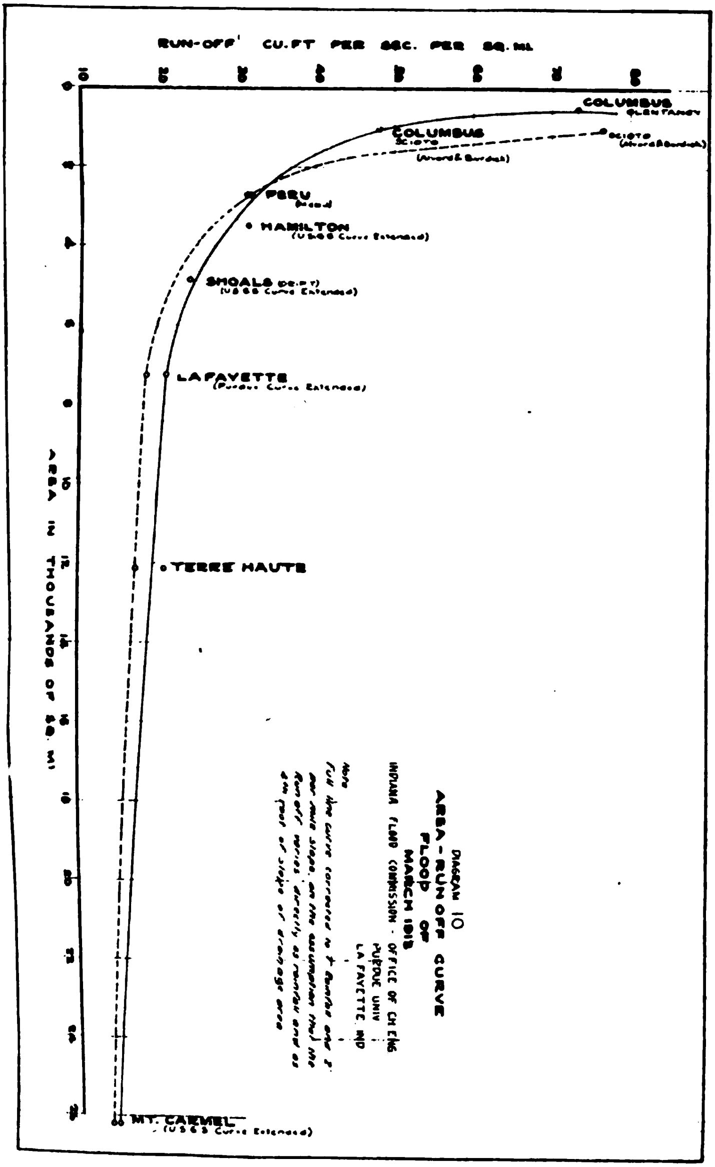

Diagram No. 10

these points during the flood conditions of March, 1913, the general slope of the drainage area, and then to apply these measurements to watersheds of like character.

Diagram 10 shows our best information of river discharge in March, 1913. The number of cubic feet per second flowing from a square mile of watershed is shown in dashed line. These all had different slopes of watershed. In full line the measurements have been adjusted to a standard rainfall of seven inches, and to a standard average slope of watershed of 2 feet per mile.

The full line may be used with a reasonable degree of certainty to predict river discharge for the White River and the Wabash River watersheds in Indiana, after making allowance for the expected rainfall and the slope of the watershed.

For example, the area of the White River watershed above Indianapolis is 1680 square miles, for which area Diagram 10 provides a discharge of 39.5 cubic feet per second per square mile, (that is for a rainfall of seven inches and a standard slope of the drainage area of two feet per mile). But the expected rainfall for 1680 square miles is (Diagram 7) 10.35 inches. The fall from the rim of the watershed to Indianapolis is 450 feet in a length of 83.5 miles, and therefore the average slope of the bed of the drainage area is 5.40 feet per mile on an average.*

To find what river discharge Indianapolis may reasonably expect to pass through its flood protection works, we must increase the rate of discharge of 39.5 cubic feet per second per square mile, above mentioned, in proportion to the probable rainfall and also increase it as the fourth root of the slope. Our computation is then as follows:

$$39.5 \times \frac{10.35}{7} \times \sqrt[4]{\frac{5.40}{2}} \times 1680 = 125{,}580 \text{ cu. ft. per second.}$$

OPENINGS REQUIRED TO CARRY RIVER DISCHARGE

The civil engineer is able to calculate the size of channel and the length of bridge opening to carry the river discharge. He must take into account local conditions, including the slope of the river bed, the alignment of the channel, whether straight or crooked, and the character of the ma-

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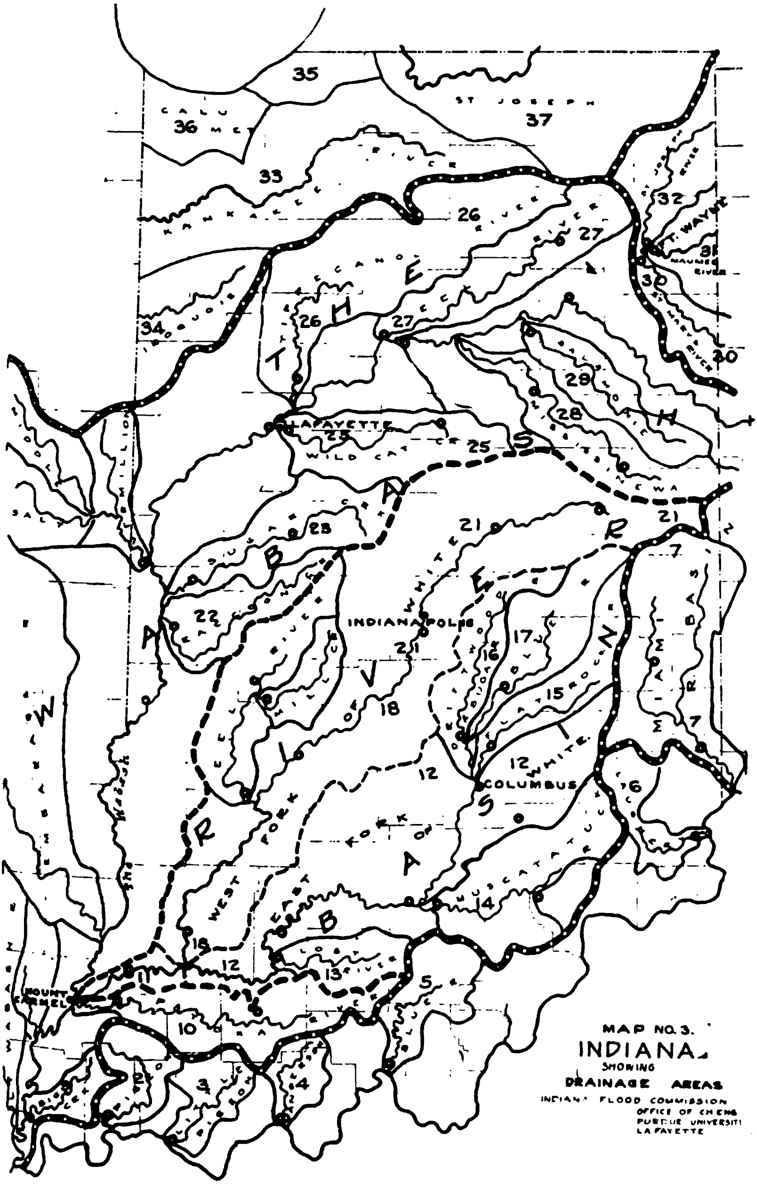
*The slope of the river channel is less than the slope of the drainage area. For the White River above Indianapolis the average channel slope is 3.41 feet per mile.


MAP NO. 3.
INDIANA
SHOWING
DRAINAGE AREAS
INDIANA FLOOD COMMISSION
OFFICE OF CH ENG
PURDUE UNIVERSITY
LA FAYETTE
35
CALUMET
36
ST JOSEPH
37
33
KANKAKEE RIVER
26
27
32
FT. WAYNE
31
MAUMEE RIVER
30
TIPPECANOE RIVER
EEL RIVER
34
IROQUOIS
THE
WABASH
LAFAYETTE
25
WILD CAT CR
28
SALAMONIE
MISSISSINEWA
SALT
VERMILLION
23
SUGAR CREEK
21
WHITE RIVER
22
RACCOON CR
INDIANAPOLIS
17
16
15
FLAT ROCK
12
WHITE
COLUMBUS
18
WEST FORK
EAST FORK
14
MUSCATATUCK
7
WHITEWATER
6
13
LOST RIVER
5
BLUE
10
PATOKA RIVER
MOUNT CARMEL
11
2
3
4
RIVER BASIN

Map No. 3

A COMPARISON OF DRAINAGE AREAS

STREAM	AREA Square Miles Illinois	AREA Square Miles Indiana	AREA Square Miles Ohio	Total	Per Cent. of State	Percentage Taken Separately			Total Length of River	Mean Slope of Drainage Area	Rainfall, 23–27, Mar., 1913
									Miles	Ft. to Mile	In.
WABASH SYSTEM	**9,028**	**23,829**	**358**	**32,215**	**66.1**	**100.0**	-----	-----	-----	-----	**6.6**
White River*	-----	11,281	-----	11,281	**31.2**	**47.3**	**100.0**	-----	-----	-----	**7.8**
West Fork	-----	5,371	-----	-----	14.8	-----	47.6	100.0	-----	2.22	7.5
Eel River	-----	925	-----	-----	2.5	-----	-----	17.2	91	5.47	6.4
Mill Creek	-----	285	-----	-----	0.8	-----	-----	5.3	51	5.01	5.25
Other Streams	-----	4,161	-----	-----	11.5	-----	-----	77.5	-----	-----	-----
East Fork †	-----	5,910	-----	-----	16.4	-----	52.4	100.0	-----	4.22	8.1
Lost River	-----	348	-----	-----	1.0	-----	-----	5.9	70	11.71	7.8
Muscatatuck River	-----	1,108	-----	-----	3.1	-----	-----	18.7	52	6.0	8.4
Flat Rock River	-----	516	-----	-----	1.4	-----	-----	8.7	88	5.7	9.7
Driftwood River ‡	-----	549	-----	-----	1.5	-----	-----	9.3	72	5.8	7.5
Blue River	-----	644	-----	-----	1.8	-----	-----	10.9	74	5.7	8.00
Other Streams	-----	2,745	-----	-----	7.6	-----	-----	46.5	-----	-----	-----
Wabash River	**9,028**	**12,548**	**358**	**21,934**	**34.9**	**52.7**	**100.0**	-----	**482**	**1.39**	**6.2**
Big Creek	-----	198	-----	-----	0.5	-----	1.6	-----	40	3.95	6.0
Patoka River	-----	895	-----	-----	2.6	-----	7.2	-----	148	2.26	7.5
Raccoon Creek	-----	519	-----	-----	1.4	-----	4.1	-----	65	12.00	8.4
Sugar Creek	-----	519	-----	-----	1.4	-----	4.1	-----	65	12.00	8.4
Sugar Creek	-----	875	-----	-----	2.3	-----	7.0	-----	80	6.56	5.64
Wild Cat Creek	-----	769	-----	-----	2.1	-----	6.1	-----	64	5.92	6.5
Tippecanoe River	-----	1,889	-----	-----	5.2	-----	15.0	-----	183	3.22	4.96
Eel River	-----	864	-----	-----	2.4	-----	6.9	-----	79	3.23	5.5
Mississinewa River	-----	855	-----	-----	2.4	-----	6.8	-----	124	3.1	8.06
Salamonie River	-----	528	-----	-----	1.5	-----	4.2	-----	85	6.7	7.0
Other Streams	-----	5,086	-----	-----	14.1	-----	40.5	-----	-----	-----	-----
Little Wabash River	3,517	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Embarras River	2,367	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Vermilion River §	1,538	70	-----	1,608	0.2	-----	0.6	-----	-----	-----	5.5
Other Streams	1,606	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
MAUMEE SYSTEM	-----	**1,186**	-----	-----	**3.3**	**100.0**	-----	-----	-----	-----	-----
Maumee River	-----	**266**	-----	-----	**0.7**	**22.4**	-----	-----	**25**	-----	**5.36**
St. Joseph River	-----	581	-----	-----	1.6	49.0	-----	-----	31	-----	5.39
St. Mary's River	-----	339	-----	-----	1.0	28.6	-----	-----	39	2.8	7.31
OHIO SYSTEM	-----	**5,733**	-----	-----	**15.9**	**100.0**	-----	-----	**351**	**6.3**	**7.0**
Miami River	-----	**97**	-----	-----	**0.3**	1.7	-----	-----	-----	-----	10.17
Whitewater River	-----	1,318	21	1,339	3.7	23.0	-----	-----	‖ 17	¶	9.3
Pigeon Creek	-----	324	-----	-----	0.9	5.6	-----	-----	36	7.7	5.52
Little Pigeon Creek	-----	369	-----	-----	1.0	6.4	-----	-----	41	5.8	5.60
Anderson River	-----	273	-----	-----	0.8	4.8	-----	-----	41	13.4	5.78
Blue River	-----	452	-----	-----	1.2	7.9	-----	-----	65	6.6	6.14
Laughery Creek	-----	354	-----	-----	1.0	6.2	-----	-----	57	14.3	7.17
Other Streams	-----	2,546	-----	-----	7.0	44.4	-----	-----	-----	-----	-----
Other Streams	-----	**5,297**	-----	-----	14.7	-----	-----	-----	-----	-----	-----
Total Area of State	**9,028**	**36,045**	-----	-----	100.0	-----	-----	-----	-----	-----	-----
Percentage of Wabash System	27.2	71.0	1.8	100.0	-----	-----	-----	-----	-----	-----	-----

*Length, 50 miles; area, 176 square miles. † Including White. ‡ Including Sugar Creek. § Including Lt. Vermillion. ‖ East Fork, 52; West Fork, 67. ¶ E. Fork, 8.9; W. Fork, 4.5.

terial in the river bed. A steep slope with rock river-bed will permit a small channel where high velocities will not interfere with navigation.

It is impracticable to draw general rules to fit these local conditions in advance. As a rough estimate it may be stated that the velocities in improved river channels should not exceed six feet per second average velocity, and through bridge openings should not exceed eight feet per second.

For instance, in the case of Indianapolis, there is indicated on this basis an area of channel of $\frac{125{,}580}{6} = 20{,}930$ square feet, and openings through bridges of 15,700 square feet. In this case the local conditions of the streams should be studied to see if such velocities can be obtained under the hydraulic characteristics of the channel.

The Indiana Flood Commission has made a special study of bridge openings in this state, and has collected statistics showing the bridge openings in our important streams and noting whether or not they were damaged in the flood of March, 1913. This study will not only serve to determine the measure of protection of these structures, against floods, but will serve as a basis for rules to determine the proper size of bridge openings in the future.

TESTS OF STANDARD AND CLASP BRAKE RIGGING FOR PASSENGER TRAIN SERVICE

By E. F. Lickey, M. E., '09

The purpose of the following article is to give in a brief and readable manner a synopsis of the results of a series of tests made to determine the relative advantages of standard and clasp brake rigging when used in passenger train service. It should be understood that the following is a summary of the tests in which the writer was one of the engineers securing the data and afterwards formulating the same. A good portion of this article is necessarily therefore an extract of the original report submitted to the officials of the Lake Shore & Michigan Southern Railway.

Several years ago the L. S. & M. S. Ry., in common with other roads, had a great deal of trouble with slid flat wheels caused by the heavy braking pressure necessary on account of the increased weight of equipment and aided by the cold winter weather and frosty rails. It became so serious and so many passenger cars were cut out on account of flat wheels that something had to be done.

The clasp brake was proposed as a means of overcoming the trouble. This type uses two brake shoes per wheel as compared with one shoe per wheel in the standard brake rigging. The standard brake rigging has many disadvantages, among which are the following:

(a) The journal is forced out from under its bearing with resultant bad effects. This is shown in Figs. 1 and 2.

(b) Considerable side pressure of the journal box against the pedestal is produced and a consequent tendency to slide wheels.

(c) Braking force is reduced on account of a considerable horizontal travel of brake shoes with corresponding increase of piston travel.

(d) Shoe wear is very rapid and the coefficient of friction varies widely.

It was thought that the clasp brake would:

(a) Maintain more uniform piston travel and insure greater flexibility for service braking and higher cylinder pressures in emergency application.

(b) Shorten the stopping distance.

(c) Reduce the tendency to slide wheels.

(d) Prolong the life of brake shoes.

(e) Relieve the journal bearings, pedestals, etc., of unbalanced pressures tending toward displacement of parts.

(f) Improve the action of the brake in regard to smoothness and uniformity of stops.

In order to determine what advantage, if any, that the clasp brake arrangement possessed over the standard foundation brake rigging, a series of tests were made near Toledo, Ohio, by a corps of engineers representing the Westinghouse Air Brake Company and the L. S. & M. S. Ry. The writer was among the latter. Three L. S. & M. S. steel coaches equipped with P. C. Air Brake Equipment and Standard N. Y. C. Lines foundation brake rigging, and three similar cars with the same air brake equipment but with clasp brake rigging were used in the tests.

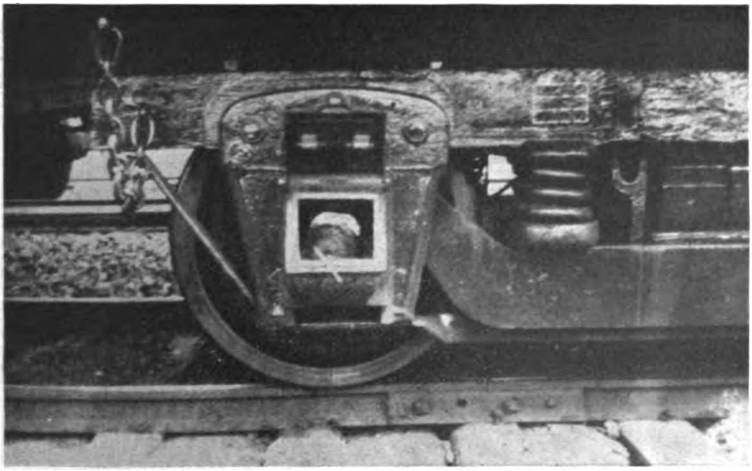


Fig. 1

The tests were made on a stretch of track picked on account of its freedom from traffic at certain hours and it being as straight and level as possible.

The track was wired with circuit breakers, the latter being connected with a chronograph in a station alongside the track. The first car was arranged with a suitable wipe to engage the circuit breakers. The engine was equipped with a trip mechanism so that it was cut off from the train and gradually pulled away from the latter when a test was made. This was necessary on account of the tests being practically all break-away; that is, the engine was cut loose from the train so as to eliminate as many variables in the weight of engine and tender as possible.

The method of conducting the tests may be of interest. Everything being in readiness the engine with train would back up several miles, the distance depending on the speed desired at the trip. They would then come ahead judging their speed from a Boyer recorder on the engine and by experience. At the trip the engine was cut loose from the train, the latter being braked by making the desired brake pipe reduction. Brake cylinder pressures were secured by indicators attached to the same, while length of stop, speed wheels slid, etc., were also secured.

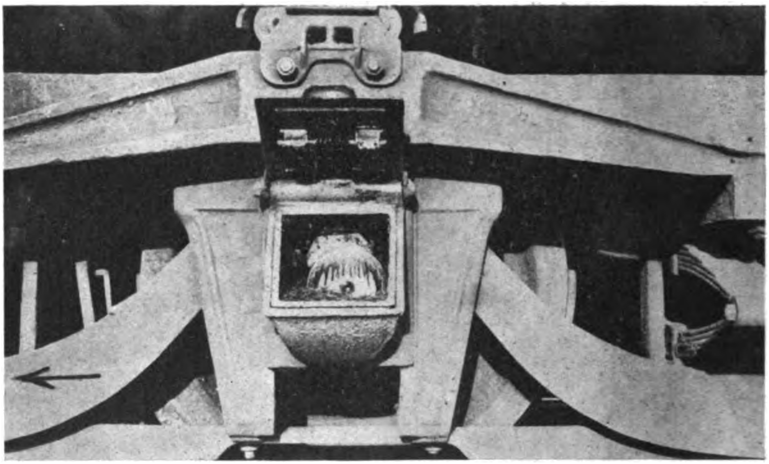


Fig. 2

The results of each test when made were tabulated on a general log kept at the chronograph station. The data secured were carefully checked and rechecked to be sure of eliminating inaccuracies. Numerous curves were plotted, among these being speed time, speed distance and resistance curves. From these curves and from a study of the data obtained certain conclusions were drawn as shown in the following:

1. LENGTH OF STOP WITH STANDARD AND CLASP BRAKE RIGGING

Under like conditions of standing piston travel and brake pipe pressure, the clasp brake cars stopped slightly shorter than the standard brake cars. This difference was in accordance with the higher cylinder pressures obtained on the clasp brake cars as compared with what was obtained on the standard brake cars, resulting from the better efficiency of the clasp brake arrangement in preventing as great an increase in emergency running over service standing piston travel as was obtained with the standard brake arrangement.

When the release springs were removed from the clasp brake cars, the operation of the equipment indicated that entirely satisfactory service would be obtained with release springs of much less strength than those applied to these cars and as far as could be observed, no release springs were needed with clasp brake cars. The stops with release springs removed were approximately 50 ft. (about 6 per cent.) shorter than in tests with the release springs applied, made three days before, but the trials were not carried far enough to prove how much of the difference was due to this change and how much to other causes which resulted in more or less change in stopping distance under equivalent conditions throughout the tests.

2. BRAKING POWER REQUIRED ON CLASP BRAKE CARS TO INSURE PRACTICALLY THE SAME STOP AS PRESENT STANDARD BRAKE RIGGING

The records indicate that with approximately 150% nominal emergency braking power on the clasp brake cars and 170% nominal emergency braking power on the standard brake cars, the difference in running piston travel with the two equipments, (1⅝" average increase with 150% braking on clasp brake cars and 5" average increase with a 170% braking power and standard rigging) will be such that the actual per cent. of braking power realized will produce approximately the same stop with each type of rigging.

3. UNIFORMITY OF PERFORMANCE OF STANDARD AND CLASP BRAKE CARS, IN EMERGENCY STOPS

The stops with the three clasp brake cars vary through a considerably narrower range than those for the three standard brake cars with the same percentage of braking power, which indicates that the clasp brake insures a greater uniformity of brake action.

For example, the variation in rate of retardation of the clasp brake cars on different tests under similar conditions amounted to only about 6 per cent., while for the standard brake cars, the corresponding variation is 30 per cent.

The single car emergency tests, made to find out if there was any greater variation in rates of retardation on individual cars with the standard than there was with the clasp brake, indicated that on the basis of the same amount of braking power, the individual cars varied but little and approximately the same amount for both types of rigging (7.65% for the clasp brake and 6% for the standard brake.)

4. Coefficient of Brake Shoe Friction with One Brake Shoe per Wheel and With Two Brake Shoes per Wheel

The results of the tests do not show that any consistently higher average coefficient of brake shoe friction was realized on the cars having two shoes per wheel than on the cars having one shoe per wheel.

5. Wheel Sliding with Clasp and Standard Brake Cars

On the high speed track with the clasp brake cars the longest slide with any of the percentages of braking power used either in emergency or service application was 35 ft. for one pair of wheels. In similar tests with the standard brake cars no sliding occurred in service application but in emergency applications individual pairs of wheels (always middle pairs) slid occasionally. The longest slide recorded was 585 ft. Next in order of length came one each of 330 ft., 125 ft., 100 ft., 90 ft. and several more shorter slides.

6. Effect of Emergency Reservoirs Being Cut in or Out

STANDARD BRAKE CARS.

Comparative tests of standard brake cars with and without emergency reservoirs average 1136 ft. stop from 60 miles per hour with the emergency reservoirs cut out and 970 ft. for the reservoirs cut in. This shows that there was an average increase of about 166 ft. in the length of stop when the emergency reservoirs were cut out.

However, it should be observed in this connection, that there is as great a difference as this between the best and the poorest stops made with the standard brake cars and the emergency reservoirs cut in.

Thus the cutting out of the emergency reservoirs does not necessarily influence the length of stop any more than may result from other causes, such as condition of brake shoes, when all conditions were supposed to be the same.

CLASP BRAKE CARS.

Practically the same relation between the emergency stops with emergency reservoirs in and out was found to exist with the clasp brake cars as indicated above for the standard brake cars. With the emergency reservoirs out, an average stop of 1084 ft. was obtained and with the emergency reservoirs in, the stopping distance averaged 944 ft., or an average increase of 144 ft. when the emergency reservoirs were cut out.

7. TOTAL LEVERAGE RATIO WITH CLASP BRAKE CARS

The average increase in emergency running piston travel over service standing piston travel, averaged from all runs in the log, was 2″ for the clasp brake rigging and 5″ for the standard brake rigging, both at nominally 170% braking power. The maximum increase for the clasp brake cars was 3⅛″ and for the standard brake cars 6½″.

If it is assumed that an increase of 2½″ piston travel is not objectionable, the total leverage ratio on the clasp brake cars can be increased from about 5.6 to 1 (as it averaged for the cars used in these tests) to about 8 to 1, with maximum emergency braking power 150%, should such a leverage ratio be found desirable in order to permit the use of smaller size brake cylinders and still insure satisfactory results.

8. EFFECT OF CLASP AND STANDARD BRAKE RIGGING ON THE MOVEMENT OF THE JOURNALS, SIDE PRESSURE AGAINST PEDESTALS, DISTRIBUTION OF BRAKING FORCES

With the standard brake rigging it was observed that the high pressure exerted by the single shoe on one side of the wheel, tilted the brasses sufficiently to lift one side of the brass a considerable distance away from the journal, so that a wide space was open for waste to be caught between the brass and the journal when the brake was released. One instance was observed when on a service application of the brake, waste was found wrapped around the journal. The collar was forced nearly and in some cases quite to the side of the box and in all cases the boxes were forced tightly against the pedestals. See Figs. 1 and 2.

These effects were not confined to emergency applications but were also noted in service applications of the brake and are all in the direction of producing hot boxes and rough riding during brake applications. The binding of the boxes against the pedestals and the unequal distribution of the percentages of braking power with the single brake shoe per wheel, also tend to produce slid flat wheels.

With the clasp brake arrangement none of the effects just mentioned existed.

9. SERVICE APPLICATIONS WITH STANDARD AND CLASP BRAKE RIGGING

While the records show but a slight difference in length of stop in service applications in favor of the clasp type of brake rigging, there was a marked improvement in the riding of the cars during service stops with the clasp brake cars as compared with those of the standard brake cars, with less displacement of trucks, journals, etc.

10. RELATIVE WEAR OF BRAKE SHOES WITH STANDARD AND CLASP BRAKE RIGGING

While there was no record of the amount of brake shoe wear by weighing the shoes, it was observed that the shoes wore down much faster with the standard brake rigging than with the clasp brake rigging. While used shoes were applied to all cars at the beginning of the test, some of the shoes on the clasp brake cars had not been worn down to a full bearing at the conclusion of the tests. The shoes on the standard brake cars wore down to a bearing in a few days, but in some cases did not hold this bearing but warped away from the wheel so that the amount of surface in contact was changing from day to day.

11. RELATIVE HEATING OF WHEELS AND SHOES WITH CLASP AND STANDING BRAKE RIGGING

It was noted that the temperature of both wheels and brake shoes with clasp brake cars was uniformly much lower than with the standard brake rigging, which would reduce to a minimum the heating of tires and damage to wheels and prolong the life of the brake shoe.

The tests discussed briefly above brought out conclusively that the clasp brake was the proper design of brake for use on heavy passenger equipment. The increasing tendency toward all steel cars has made necessary a design of brake which will be sufficient to give a stopping distance in both service and emergency equal or better than that obtained with the standard brake and do this without sliding wheels. The fact that practically all new passenger cars purchased on the N. Y. C. Railroad have the clasp brake and that little or no trouble is experienced with slid flats must be considered as favorable to the new design.

A NEW SOLUTION FOR THE PROBLEM OF SELECTIVITY IN TORPEDO CONTROL

By B. F. MIESSNER, E. E., '17

The recent War Department tests of the Hammond Wirelessly directed torpedo, which has been reported from many authoritative sources as the most formidable weapon of destruction ever developed for naval warfare and the many newspaper accounts and editorial comments occasioned by the remarkable success achieved in these tests, makes a discussion of the solution of one of the chief problems encountered particularly interesting at this time.

A practical, shore-directed torpedo has, for years, been one of the wildest dreams of Naval and Army officers. Given a high speed, semi-submerged vessel, carrying a sufficient charge of high explosive material to blow the biggest dreadnaught virtually into pieces, and a reliable and accurate means of guiding it from a distance. With these a nation need never fear invasion by sea: A large number of these torpedoes (a thousand of which could be built for the cost of a single battleship) scattered along the coast with wireless control stations for operating them would, indeed, afford a most effective means of coast defense.

The realization of these facts as long as twenty years ago led inventors and scientific men to focus their attention on the development of a dependable means of distant control for self propelled boats. Now, at the end of two decades of work by investigators in all quarters of the globe twenty years of endeavor, failure, and minor successes—we are at last upon the threshold of a new era in Naval warfare, an era fraught with possibilities, the perception of which even by the veriest layman, requires no over-exercise of the imagination. An era of WARFARE we say, and yet can we help but say of PEACE as well, for is it not true that every engine of destruction conceived by man is also a weapon of construction? Does not every death dealing instrument of war tend to avert the very end for which it was created? Does not every new advance in the science of human slaughter make war more and more horrible and humanity less and less tolerant of these relics of barbarism, these present-day methods of settling international difficulties, which even now are exacting their tremendous revenue of human life and misery?

Considered broadly the two greatest difficulties to be overcome in the evolution of a serviceable dirigible torpedo, have been,

1. The lack of a reliable means of transmitting and receiving a sufficient amount of energy to actuate the control apparatus at useful distances.

2. "The Selectivity" problem. This, stated simply, is to provide a means of allowing the shore station to direct its torpedo unhindered by the attempts of the hostile battleships to interfere.

The first of these difficulties has only been surmounted within the last three years; the second, though not yet completely solved, is well on the way and bids fair to make complete the realization of the invention's possibilities. The fact that Mr. Hammond has successfully controlled a high speed, explosive-laden boat at distances up to thirty miles from the transmitting station while deliberate attempts to interfere were being made by nearby wireless stations, furnishes proof enough to convince the most skeptical, of the invention's value in defending the extended coast lines of the United States.

The selectivity problem, which is the greatest by far of all obstacles to be overcome in the successful evolution of a wirelessly controlled torpedo is one of comparative difficulty depending upon the degree of non-interferability desired.

A selective receiver may be likened to a safety vault. The transmitter corresponds to the owner of the safe and he alone possesses the combination. No safes are absolutely burglar-proof, and their value depends principally upon the length of time required for a skilled cracksman to reach the inside. Likewise no receivers are absolutely selective for the simple reason that an operator of another station bent on interfering can take observations and measurements on the signals sent out to the selective receiver (just as a burglar may watch the opening of a safe by the owner) and adjust his own apparatus to emit waves of exactly the same characteristics as those of the transmitter designed and adjusted for the selective receivers operation.

The burglar, instead of trying to learn the combination of a safe, may use sheer force in reaching the inside; an explosion of nitro-glycerin for example. In the same manner a hostile transmitting station can perform the desired effect in the selective receiver, i. e., operate the receiving relay, by the emission of very strong signals, so that forced oscillations are set up. This is known as the "whip crack" effect and it is believed that very few receivers are immune from it.

The best wireless signalling sets, such as those used by the United States Navy, are considered very selective and yet the interference existent between them is quite serious. Take for example: Washington is receiving a message from the Eiffel Tower Station in Paris which is sending at 3,000 meters wave length. It is easily possible for a station in California with an equal amount of power and at practically the same distance to make the Paris message unintelligible at Washington simply by sending signals at or within, say, two or three per cent. of 3,000 meters wave length.

Again, some insignificant station, with little power and within a few miles of Washington, could make it practically impossible for Washington to receive any messages at all from distant stations, by sending out broadly tuned signals of high damping. These highly damped, or untuned signals, by the previously mentioned whip crack effect, cause the receiving antennae to vibrate in their own periods regardless of what these periods may be and thereby produce a great deal of interference. To illustrate: sing a clear, steady tone into a piano. The string, which when struck, emits that tone will audibly vibrate in resonance. Then shout loud and gruffly into the same piano; practically every string will be set in vibration thus producing a dull roar. The first tone corresponds to the signals sent out by tuned transmitters; the second (noise) to the whip crack signals emitted by an untuned transmitter.

Another comparison might serve to illustrate, the degree of selectivity necessary for torpedo control. We have three persons, A, B, and C. A and B are together at one place and C is a mile away. The problem is to allow A to hear what C says while B is shouting in his ears. "Impossible," you say? Yet the torpedo problem is practically an exact analogy. We must be able to make the electro magnetic ear of the torpedo hear our control impulses eight miles away, while it is at the very side of a battleship capable of almost deafening it with a force of its own powerful signals.

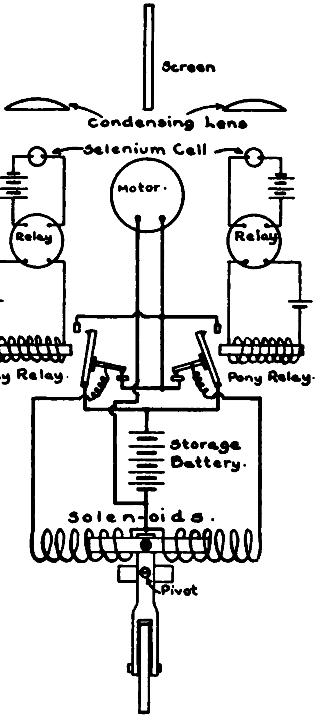
It is true we could sidetrack the selectivity problem and simply use such a large amount of energy at our shore station that more energy could be delivered to the torpedo at eight miles distance than the hostile battleship could deliver to it at a hundred feet. This is possible because the amount of energy that can effectively be used aboard a modern battleship does not greatly exceed five K. W. This is due to the limited size of the antenna. A shore station, with practically no limits on the size and height of its antenna, can easily use 100 K. W. The shore station also has the additional advantage of being able to direct its energy somewhat in the general direction of operations. This can be accomplished either by the use of an inverted "L" type antenna with a flat top, long, in proportion to its height, as suggested by Marconi, or by the use of the Bellini-Tosi Radio Goniometer.

Side stepping the problem, by using a land station of tremendous power is, however, not the practical and efficient solution. In the first place although desirable, absolute selectivity is not necessary. A receiver that would require, say, fifteen minutes time for the enemy to learn its combination, that is, the characteristics of its operative wave, would in all probability satisfy the requirements. In that length of time the torpedo would very likely have completed its work of destruction.

Since the problem of securing a sufficiently high degree of selectivity to insure non-interferability has been attacked from many different sides, without the desired results. Those engaged in this work have cast about for paths which might lead to the solution of the real problem. This, after all is not one of selectivity, although heretofore looked upon as such but it is simply one of preventing interference. A safe manufacturer, instead of devoting his entire attention to developing complicated combination locks or explosion-proof vaults, might arrive at the same desired end, namely to keep burglars out by an entirely different route. This might be accomplished by electrifying the safe with powerful apparatus within it so that the burglar would not dare to tamper with it for fear of being his own executioner.

The problem of selectivity likewise can be cast aside as one of secondary importance and the real problem of keeping the enemy from tampering with the torpedo by means of their own wireless transmitter, solved by the use of apparatus which will make them their own executioner.

In 1912 the writer, associated with John Hays Hammond, Jr., developed an apparatus which we have called "An Orientation Mechanism." The principle involved in this machine has been applied to torpedo control with this same idea of making it hazardous for the enemy to attempt interference. This orientation mechanism which has also been popularly called the "Electric Dog," in its present form, consists of a rectangular box about three feet long, one and a half feet wide, and one foot high. This box contains all the instruments and mechanism, and is mounted on three wheels, two of which are geared to a driving motor, and the third, on the rear end, is so mounted that its bearings can be turned by electro magnets in a horizontal plane. Two five inch condensing lenses on the forward end appear very much like large eyes.



Wiring Diagram- Electric Dog

Fig. 1

If a portable electric light be turned on in front of the machine it will immediately begin to move toward the light, and moreover, will follow that light all around the room in many complex manoeuvers at a speed of about three feet per second. The smallest circle in which it will turn is of about ten feet diameter this is due to the limiting motion of the steering wheel.

Upon shading or switching off the light the dog can be stopped immediately but it will resume its course behind the moving light so long as the light reaches the condensing lenses in sufficient intensity. Indeed, it is more faithful in this respect than the proverbial ass behind the bucket of oats. To the uninitiated, the performance of the pseudo dog is very uncanny.

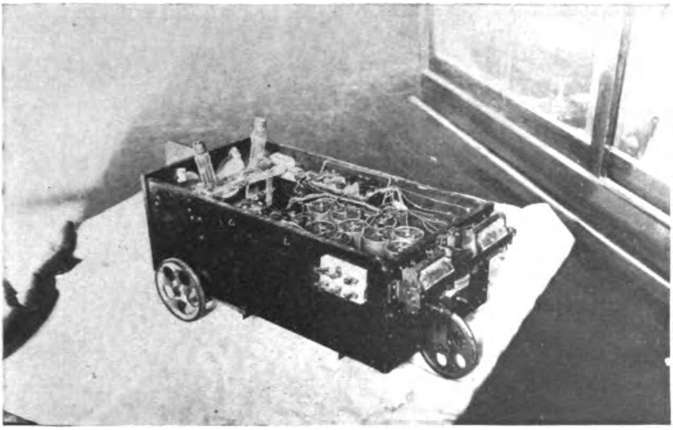


Fig. 2

The explanation is very similar to that given by Jaques Loeb, the biologist, of reasons responsible for the flight of moths into a flame. According to Mr. Loeb's conclusion, which is based on his researches, the moth possesses two minute cells, one on each side of the body. These cells are sensitive to light, and when one alone is illuminated a sensation similar to our sensation of pain is experienced by the moth; when both are equally illuminated, no unpleasant sensation is felt. The insect therefore keeps its body in such a position, by some manner of reflex action, as will insure no pains, and in this position the forward flying motion will carry it directly toward the source of light.

The orientation mechanism possesses two Selenium cells, corresponding to the two light sensitive organs of the moth, which, when influenced by light effect the control of sensitive relays, instead of controlling nervous apparatus for pain production, as is done in the moth. The two relays controlled by the selenium cells in turn control electro magnetic switches which effect the following operations; when one cell or both are illuminated the current is switched onto the driving motor; when one cell alone is illuminated, an electro magnet is energized and effects the turning of the rear steering wheel. The resultant turning of the machine will be such as to bring the shaded cell into the light. As soon and as long as both cells are equally illuminated in sufficient intensity, the machine moves in a straight line toward the light source. By throwing a switch, which reverses the driving motors connecting, the machine can be made to back away from the light in a most surprising manner. When the intensity of the illumination is so decreased by the increasing distance from the light source, that the resistances of the cells approach their dark resistances, the sensitive relays break their respective circuits, and the machine stops.

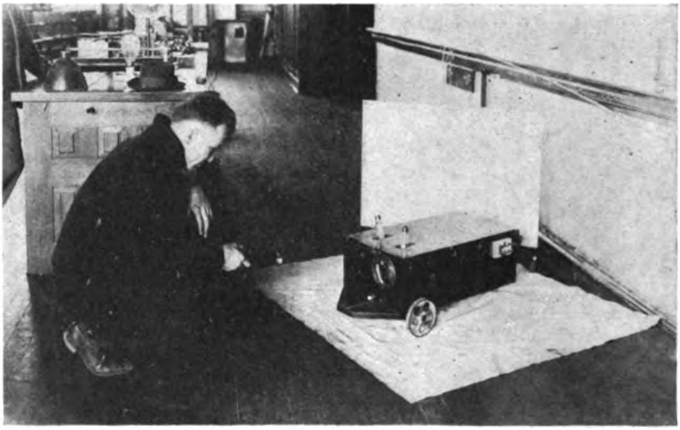


Fig. 3

The principle of this orientation mechanism has been applied to the Hammond Dirigible Torpedo for demonstrating what is known as Attraction by interference. That is, if the enemy tries to interfere with the guiding station's control, the torpedo will be attracted to it. The torpedo is fitted with apparatus similar to that of the electric dog, so that if the enemy turns their search light on it, it will immediately be guided toward that enemy automatically.

In order that the search light used by the control operator may not have this same effect, use is made of a Gyroscope to keep the turn table upon which the cells are mounted, in a fixed position relative to the earth. In this way no matter how much the torpedo turns, or in what direction it is traveling the selenium cells will always face from the shore and toward the attacking battleship in the open sea.

By means of two directive antennae, instead of two selenium cells the same principle may be applied for attraction by interference when Hertzian, instead of light waves are used. Sound waves might also be utilized in a similar manner so that the sound reaching the torpedo (which would be equipped with two submerged microphones made sensitive and directive by megaphone attachments) from the pounding of the battleships engines and other machinery, would effect its attraction in a way analogous to the attraction of a source of light for the orientation mechanism. It is just possible too, that similar apparatus could be used for the detection of submarines, or for defense against them.

PROGRESS IN METHODS OF WATER PURIFICATION

By C. A. JENNINGS, Purdue, '06

Although alum was used in Egypt many years ago to clarify water, nevertheless very little was done toward purifying water until the last century. The underground sources of water supply were usually sufficient to furnish all the water needed. As cities grew in size, it became necessary in many cases to find sources of water supply more ample for the present and future needs. Many cities began to use surface water supplies. Incident to the growth in population and the introduction of sewer systems was the increased pollution of the surface water supplies. The new science of bacteriology, developed about the middle of the last century, showed the relationship between polluted water supplies and intestinal diseases. Means were adopted to purify as well as clarify water. Storage reservoirs, settling basins and filters then came into use. For various reasons the installation of filters (slow sand and rapid sand or mechanical) was more widely adopted than other methods of purification. Principally this was due to their adaptability to almost any topography, capability of handling water of any character and their compactness. The rapid and phenomenal growth of filtration in the United States is shown in the following table compiled by Mr. Geo. A. Johnson of New York. This table shows the population supplied with filtered water:

1870	None
1880	30,000
1890	310,000
1900	1,860,000
1910	10,806,000
1914	17,291,000

Filter plants were formerly installed with a guarantee to remove all but 2% or 3% of the bacteria in the water. As the population per square mile on the watersheds became greater and greater and the volume of sewage discharged into the streams became larger and larger, the burden placed upon the purification plants was found to be excessive. This condition called for the development of a finishing process.

About 1908 four methods of treatment supplementary to filtration and other water purification systems were developed. They were the hypochlorite, liquid chlorine, ozone and ultra-violet-ray processes. Chlorine gas, a by-product of the manufacture of soda, when passed into lead lined chambers containing dry, slaked lime, forms bleaching powder, hypochlorite of lime or "hypo" as it is called by waterworks men. The average strength of hypo, expressed as "available chlorine" is about 37%. Hypo was first used on a large scale in water work in 1908 at the Bubbly Creek filter plant at the Chicago Stock Yards. It was not used for clarifying water but for oxidizing the organic matter and killing the bacteria. It was found that this treatment seemed to have an affinity for the disease producing bacteria in water, which was the primary object of such supplementary processes. Up to 1914 some 500 cities had adopted this treatment, some using it alone as an emergency treatment while other cities used it as an adjunct or finishing process with filtration, sedimentation or storage. It has served its purpose well. Many epidemics of Typhoid Fever have been arrested and probably many more have been averted by the use of this process. It has been a cheap treatment to install and to operate and its efficiency cannot be questioned.

Within the last year or 18 months a new treatment has reached a practical working basis and has been rapidly replacing hypo treatment. This is the liquid Chlorine method of water disinfection. Chlorine gas is pumped into steel cylinders and liquified by pressure. When so prepared the gaseous or liquid chlorine will analyze 99% or more of "available chlorine." Cylinders are connected to special reducing valves and gauges and the chlorine is fed to the water under treatment usually in the form of a solution prepared by discharging the gas (the liquid chlorine becomes gaseous chlorine as it passes from the higher to the lower pressure) into an absorption tower. This is filled with some substance which will not be attacked by the chlorine and will present considerable surface for absorption of the chlorine by a stream of water which flows down through the absorption tower.

Liquid chlorine treatment is replacing hypo because usually it is cheaper, it is more efficient, its regulation and adjustment can be more easily and quickly accomplished than with hypo, the reaction is more rapid and less affected by low temperatures of water and there is less opportunity for tastes and odors resulting from liquid chlorine than from hypo treatment. In short, it seems to possess all of the advantages and only a few of the disadvantages of hypo treatment. Philadelphia, Brooklyn, Wilmington, Niagara Falls, Oklahoma City and a large number of other cities have already adopted this newly developed and newly perfected method of water disinfection. The Bubbly Creek filter plant at Chicago, the first to use hypo, has recently discarded hypo in favor of liquid chlorine.

Ozone is a gas. It is represented by the symbol O_3, that is, it is a molecule of Oxygen to which is attached an extra atom of Oxygen, which however, is only loosely held. Ozone is produced by electrical discharges through the atmosphere. To obtain the best results, the water must first be freed of suspended matter, preferably by filtration. Ozone is an oxidizing agent as are also hypo and liquid chlorine. It is more expensive to install and to operate than either of these and up to the present time, has not been reduced to a practical working basis in this country although it is said that there are several plants in successful operation in Europe.

Ultra-violet ray disinfection is accomplished by exposing water to the action of the ultra-violet rays produced by specially constructed lamps immersed in the water to be treated. These rays are strongly germicidal. However, the penetrating powers of these rays are limited so that it is absolutely necessary that the water be free from suspended matter and have a color not exceeding 15 to 20 parts per million. It is therefore evident that in order to produce reliable results, the water must first be filtered. As with ozone, this treatment is somewhat expensive to install and to operate, compared with hypo and liquid chlorine. Likewise, it has not been placed on a practical working basis in this country, although as claimed for ozone, there are numerous successful operating plants in Europe.

Thus it is seen that when the work to be done by filtration and other water purification processes became unduly heavy and the results at times questionable and unreliable, finishing processes were developed to relieve this extra task and so ensure reliable results at all times. Although all Typhoid Fever is not caused by polluted water, nevertheless most of the cases are caused by water. One of the best evidences of the efficiency of these finishing processes is the continued annual reduction in the Typhoid Fever death rates of the cities using such processes.

RECENT CONTROL REQUIREMENTS FOR ELECTRIC VEHICLES

By W. H. Holder, E. E., '05

The manner of providing for the speed control of the motor in electric vehicles is of vital importance to the car driver that he may have quick and dependable response; to the passengers, that the acceleration may be smooth; and to the one who pays for maintenance that the outfit may be efficient. The life of the controller contacts and the absence of trappy construction enter into the problem of speed control. Mileage is also increased by the elimination of I^2R losses in the controller and in the series resistances which may form a part of it.

Practically all of the motors used at present on electric vehicles are of the series type with the series field winding in two sections. The battery on the car may either be provided, permanently connected up as one group of cells, or it may be divided into two equal groups.

For the simpler type of speed control an extensively used drum type construction has been designed which gives speeds as follows:

SINGLE VOLTAGE CONTROL

1st. Field sections connected in series—two sections of series resistance.

2nd. Field sections connected in series—one section of series resistance.

3rd. Field sections connected in series—no resistance in circuit.

4th. Field sections connected in parallel—shunting resistance across fields.

With this controller the shunting resistance, which is used for weakening the field, takes very little energy and its use for moderate speed increase is considered good practice. However, considerable energy is wasted in the I^2R heat developed in the series resistance which is used on the first two running speeds; since the driver will necessarily run for a considerable portion of the time on one or the other of these low speeds.

The demand for better efficiency, longer mileage and the elimination of series resistances has brought forth another type of controller which is usually built in drum form as follows:

DOUBLE VOLTAGE CONTROL

1st. Battery sections connected in parallel—field sections in series.

2nd. Battery sections connected in parallel—field sections in parallel.

3rd. Battery sections connected in series—field sections in series.

4th. Battery sections connected in series—field sections in parallel.

With the above combination of circuits it will be noted that each one forms an efficient running point; there being no loss due to resistance and at the same time an equally wide range of speed control is obtained. The absence of resistance increases the mileage appreciably and allows maximum torque to be obtained on first point.

One of the chief advantages of this double voltage scheme of control is in the elimination of series resistance, used with the single voltage controllers, which gives the driver a great deal of trouble. This resistance burns out with annoying regularity when the operator runs the car for several miles on the low speeds. It might be thought that resistance of sufficient capacity for all emergencies could be used but if this be designed it will be found that the excessive weight and bulk make is absolutely prohibitive on pleasure cars at least, and therefore it is very frequently found that this resistance burns out, getting red hot or even in some cases setting the car on fire. With the double voltage control system one can operate on the lowest speed for any length of time, not only without troubles from burnouts but he is running under efficient conditions. The resistance used with single voltage control is designed for intermittent duty and is intended primarily for acceleration speeds and not for continuous running.

Tests made on the same car under the same conditions of road, stops and speeds, total length of run being approximately 55 miles in each case and stops being made uniformly five times per mile resulted in the following data:

Average watt hours per car mile with single voltage control—244
Average watt hours per car mile with double voltage control—208

of 17.3 percent more energy consumed by the single voltage control for the same amount of work done. For these reasons it is becoming very frequent to install double voltage control where possible.

In commutating battery connections, that is, in changing from sections in parallel to the sections connected in series, many control schemes allow the power circuit to be broken. With this type of controller if the operator does not throw the control lever from the running point where batteries are in parallel very accurately to the next point, where the batteries are connected in series, the power circuit will be opened giving an unpleasant sensation and often causing some embarrassment to the operator. In the down town traffic where automobiles are being hustled across the street by the traffic man, cars have been seen with this type of control, in which the lady operator started her car and pushed the control lever hesitatingly to the point where the power supply was cut off and her car stopped, but at the wave of the policeman the lever was inched further and the car would suddenly shoot forward necessitating a great deal of skill to prevent an accident. This excess starting current is also abusive to battery and motor.

To overcome this trouble recourse is taken to some sort of transition resistance to prevent short circuiting of the batteries while they are being commutated without cutting off the power. It might be stated that as to the necessity of a battery transition resistance, there has been developed by one concern at least, a sufficiently accurate star-wheel or notching device which really prevents the operator from pausing between points. This at least is the claim, but it is the writers' opinion that a star-wheel device of sufficiently pronounced notching to obtain this result would be entirely too tiresome to operate. The ordinary control lever, particularly for ladies' use, should have a star-wheel effect only sufficient to guide one to running points and not one strong enough to actually throw the control lever from the dead center when operating it.

The transition resistance can be worked out quite easily on the drum; the principle being to connect a resistance in shunt with the two sections of the battery while they are in parallel, then open the parallel connections for the batteries (not disconnecting from motor) leaving the two sections and the resistance in series, and afterward shorting out the transition resistance.

Similarly the circuit should not be broken when changing from field sections in series to field sections in parallel. Transition resistances of the same nature are frequently used for this purpose, but since it is possible to short circuit a section of the series field without damage, there is a preferable scheme which is worked out as follows. Have the two sections in series; first short out one of the field sections which leaves the remaining one active, then open the circuit of the section which is shorted out (without opening the line supply to the active section), then connect this first section so that it will be in parallel with the active one.

It has been found that further sub-division of the battery groups to obtain an additional number of speeds is not practical, on account of the complication of the controller and the additional wiring required between controller and battery. These items increase the cost of production—the extra leads introduce a fixed I^2R loss and further, the speeds obtainable with but two groups give smooth acceleration and (for the average maximum speed of 20 miles per hour) sufficient speed points.

As a further development of this same scheme of double voltage control there has been developed a full magnetic type of control which consists of a series of magnetically operated contactors. These switches are controlled from a small master controller which is mounted directly on the steering lever and is so small that it may be enclosed by the hand. The advantages of this magnetic scheme are in general; that it is nicer to operate, particularly for a lady; instead of having two levers to operate there is but one, the steering lever; the master controller having an entirely different motion and is therefore not as likely to be confused with the steering lever. A quick snappy action of the contactors equipped with magnetic blow-outs, reduces the arcing and deterioration of contacts to a minimum. It is easier to operate this small master than to drive a drum controller through all of the bell cranks and against the star-wheel action, with which most cars are equipped and even the battery transition resistance may be eliminated since the batteries may be changed from parallel to series connections by the operation of a single magnetic switch which operates so quickly that the momentary opening of the power circuit cannot be noticed by the operator.

In combination with the hand master controller a foot operated master may also be used; the preferable arrangement being to use the hand master primarily as a speed setting device and to connect the foot master so that when the foot is removed from it the car will accelerate up to the speed as determined by the setting of the hand master only, but the speed may be lowered by pushing the foot master and the car stopped when it is fully depressed. This scheme is very desirable in crowded traffic for quick and frequent stops and starts.

In addition to the regular functions of acceleration, speed control and reversing obtained with the full magnetic controller and its master, provision may be made for dynamic braking. A push button is added to the master which operates to close a contactor connecting a resistance in series with the motor armature and the fields after power is cut off so that if the car speed is about six miles per hour or higher a current is generated by the motor thus producing an electrical braking. This is used regularly as a service brake instead of the foot brake and a mechanical foot brake is used only for an emergency quick stop. A magnetically operated disc brake is also used by some manufacturers; this being operated also by closing its electrical circuit in the master controller. This may be used to serve the same purpose as the dynamic braking.

The character of the dynamic braking when applied is to give a peak at the start, followed by a rapidly decreasing retarding effect as the speed lowers owing to the lower electromotive force developed in the armature, whereas with the magnetic disc brake the braking effort is least at the initial application, increasing as the speed decreases on account of the increasing coefficient of friction at lower speeds.

In one make of car both types of electrically controlled braking is used. The dynamic is first applied and if not sufficient (on account of low speed) the magnetic disc brake is also used. The combination of the two applied simultaneously when properly designed gives an ideal retarding effect of practically uniform value from high to low speed; the weakening of the dynamic braking at lower speeds being equalized to a considerable extent by the increasing value of the disc brake effect.

A FEW NOTES ON SAFETY FIRST

By JOHN D. ONG, Ch., '13

Engaged in Accident Prevention Work,
with The National Malleable Castings Co., Chicago.

The Safety First movement has grown so remarkably fast and vigorously within the last three years, that it would be folly to attempt to touch all sides of the subject in an article of this length. The writer will mention only a few general points bearing on accident prevention and then cite some of the measures adopted by one company in its safety first work.

Almost all large industrial establishments have taken up the movement and the smaller ones are following. The result is that serious and fatal accidents, and occupational diseases are now almost unknown in some lines of work, where such occurrences were common only a few years ago. Other plants have materially reduced the number of serious and fatal accidents. This reduction in the number of injuries has been brought about by: first, co-operation of the men "higher up" with the Safety First movement; second, education of the employees regarding safety; third, safeguarding machines as well as the workmen.

Men as a rule resent being driven. Even the uneducated, foreign laborer doesn't enjoy it. The probabilities are that if a man is ordered to take a precaution, the reason for which he doesn't understand, he will do it but he will not feel right about it. The first chance he gets or as soon as he thinks the "boss" isn't looking, he will do it his way and disregard the precaution altogether. Especially is this true when Safety First work is being started. The man in charge must be thoroughly in sympathy with the movement. He must understand how to handle men and be able, by what he says and how he acts, to gain the good will and confidence of the men. It is the employer's duty to bring the employee to see that the chief reason for installing safety methods, is for his, the employee's advantage. This is one kind of work employees cannot be driven into—they must be led. For example, a foreman cannot give his men goggles and say: "Wear these during working hours," and expect the men to wear them without complaint if he works around without wearing them himself. The men will find a dozen objectionable features in a very short time. The foreman must practice as he preaches and take the same precautions he asks the men to take.

Very closely connected to the co-operation of the men-in-charge of the Safety First work, is that of the education of the workmen. Again, using the example cited above, if the foreman wears the goggles for a week before asking the men and explains why they are asked to wear goggles, pointing out the danger and risks taken by not protecting their eyes, then he will get satisfactory results. The men are skeptical at first as to the motive of the company and as to the advantage of wearing goggles. They should not be pushed into it too hurriedly. Employees should be taught to recognize the danger and risk they take of working unprotected; of working with unprotected machines; of working with careless men, who do not do their work in a safe way; of being careless themselves; of ignoring signs, bulletins and suggestions of safety offered by the company. They must be educated to think, feel and live "Safety First."

If the men are not moved by the proper spirit, all the safeguards on machines and all the protectors given the men will not materially reduce the number of accidents. If the workman doesn't like the guard provided, he will do his utmost to show up the disadvantages and weak points of that guard. It is not so much a question of making machines "foolproof," as it is to prevent the men from taking chances. The education of the workman is, in the writer's opinion, the most important thing of all in accident prevention work.

Different plants inaugurate and carry on their safety work along several different lines; one company believes it can best attain results by placing it in the hands of a committee of workmen; another will have a workmen's committee meet and discuss the work with some of the men in charge of the plant; another will depend on the superintendent, foremen and bosses to carry on the movement. Some companies offer prizes to the workmen who submit practical safeguards or safer methods for doing a certain piece of work; other concerns object to giving prizes or money for suggestions, and many plants rely on the men to obey the notices, warnings and bulletins which appear from time to time on the bulletin boards in the yards and buildings. Each method has its good points and it is very much a matter of local conditions which will be the most effective in any one plant.

To give an idea of what The National Malleable Castings Company is doing for its men, a few of the precautions taken to prevent accidents will be indicated. Proceeding on the belief that a disabled or unhealthy employee is dangerous to his healthy and physically able fellow worker, all men are given a physical examination on entering the employ of the company. It is determined if the applicant's sight, hearing and heart action are good, if he has any physical deformities, such as flat foot, hernia, missing fingers, impaired use of either hands or legs, old sores or wounds. The company does not expect perfect men, but it does want sound men. The applicant is questioned concerning his knowledge of the work he is to do, especially what his course of action would be in case of accident. The employee is urgently requested to report to the doctor's office every time he meets with an accident, no matter how slight the scratch or how trivial the cut or burn. Failure to report the accident may be sufficient cause for laying off or discharging the employee.

All goggles, hand leathers, leggings and knuckle guards mentioned later in this article are sold to the men at cost price, are repaired, replaced or improved free of charge. When the man leaves the employ of the company he is refunded the original cost of them. Molder's shoes are sold at cost, but are not repaired or replaced.

If the new man be a molder, he is fitted with a pair of light goggles, a canvas legging, which protects the leg nearest the hand ladle when pouring-off, and a pair of molder's shoes, for no lace or button shoes are permitted on account of the danger of melted iron lodging in the shoe lacing with the resultant burns. The legging extends from a few inches above the knee to the ankle, covering the top of the shoe, so that there is no place for iron to lodge. All men working around melting furnaces at pouring-off time are required to wear goggles, for it was formerly found that there were frequent eye injuries due to spattering when the melted iron struck a "green" ladle, or wet mold weight. A foundry laborer, who shakes out molds, shifts mold weights and handles pig iron and sprue, is provided with hand leathers. These are a sort of crude leather glove especially designed to protect the ends of the fingers, and prevent hot sand from burning the wrist. Wheelers and truckers are provided with handleathers and goggles. Outside of the foundry all workmen must wear goggles during working hours. Molders and molders' helpers are required to wear goggles only while pouring-off. As in the case of not reporting accidents, failure to wear goggles may mean suspension of the employee.

Men in the trimming room, who handle only the smaller castings are provided with knuckle guards of leather. Trimming room men as well as those working in the straightening and fitting departments are provided with goggles having a light, fine-mesh wire gauze at the sides of the lenses, to prevent chips from striking the eyes from the sides. Grinders who must work close together are also fitted with this style of goggle. Workmen in the annealing, rolling, slag and sprue, machine, carpenter and pattern departments are fitted with a light weight plain goggle similar to the style used in the foundry. Employees in the machine, carpenter and pattern shops are required to wear their goggles only on certain kinds of work.

Eye injuries have been reduced from an average of 20 to 2 or 3 a month. Where formerly there were many serious eye accidents, the present ones are only minor eye injuries. When the $^9/_{64}$-inch thick lens of the chippers' and trimmers' goggles are broken by a chip or test lug, and the eye is found to be uninjured, the advantage of wearing goggles will be recognized.

Belts, which are in any way close to or which are liable to be brushed into by workmen, are guarded. Gears are covered wherever there is a possibility of an employee getting a finger caught. Irregular lathe chucks are covered. Emery wheels are covered almost entirely by an iron guard and where the nature of the work permits, a small glass guard is placed between the operator's face and the work, allowing the man to see his work, but which prevents sparks from flying into his face and eyes. Two emery wheels are mounted on each machine and a canvas guard between the two wheels prevents the sparks of one wheel from striking the workman at the adjacent wheel. Where two machines are close together, a canvas guard is placed between machines. The eye accidents in the grinding department have dropped about 90 per cent. since the installation of these guards and wearing of goggles by the men.

Drop hammers, air hoists, chain tackles, traveling cranes and elevators are inspected daily, to make sure that they are in a safe working condition. Drop hammers are provided with a safety device which prevents hammer from dropping if hammer release is accidentally tripped. Wheelbarrow handles are equipped with knuckle guards, which prevent injury to workmen's hands while passing through swinging doors or along passageways. Chisels of all kinds are inspected regularly for "mushroomed" heads; if any are found they are ground or taken to the blacksmith shop for reheading. Hammers are inspected to see that the faces are not chipped and under size.

Bulletin boards are placed at the main gates. Bulletins, some of which are furnished by the National Council for Inlustrial Safety, are changed weekly. A pair of broken goggles are generally placed in the bulletin board with a short note attached, stating how the accident occurred and that the goggles probably saved an eye.

Accidents occur even with all the precautions that are being taken, but the attendant in the doctor's office isn't nearly so busy as he was 18 months ago. A practicing physician attends to the more serious cases daily. Doctors' and hospital bills are paid by the company. Of course, it costs quite a little to look after the health of the men, to install and maintain the safeguards on machines and the protectors given to the men, but it most certainly pays. It makes the employee feel that the company is doing what it can to protect him from injury. It gives him a contented feeling and he will do better work, work more earnestly and efficiently if he is provided with a safe place to do his work. When a new man begins his work he doesn't see why it is insisted that he take so many precautions. He is tempted to laugh at and ignore the Safety First policy, but he soon learns that it pays to be on the safe side.

The plants of the National Malleable Castings Company are not the safest ones to work in by far, but they are continually trying to improve and increase the number of safety devices and to remedy dangerous operations. The success in getting the men, mostly foreigners, to participate in this Safety First work, has been due, largely to the way in which the matter has been up to the men, and to the interest which the officials have shown at all times and the personality they have put into it. May the good work go on.

THE CONSTRUCTION OF LOCKS AND DAMS ON THE OHIO RIVER

By F. A. Irick, C. E., '11

With a view to obtaining a navigable depth of nine feet throughout the entire length of the Ohio River, congress, in the river and harbor act, approved June 25, 1910, adopted a project for its complete canalization by a system of locks and dams. The project included the construction of 54 locks and dams at an estimated cost of about $1,180,000 each, and it was required that the work be completed in 12 years.

The boats used on the Ohio River are of light draft and of the usual river type, the packet and tow boats having drafts of from two to six feet. The packet trade in recent years is but a small per cent. of what it was before the day of railroads. This is due largely to the fact that it is possible to depend on a river stage sufficient to transport a boat of even two foot draft but a short time during the year. The greater part of the present traffic is coal and iron products from the Pittsburg district to lower Ohio and Mississippi River and gulf points. The loaded steel and coal boats require for their transportation about a ten foot stage which seldom is maintained but a short time between the months of June and December; and during the winter months, when usually the stage is sufficient for transportation, much of the time the channel is obstructed by ice. When the entire project is completed there will be maintained throughout all seasons of the year a minimum channel depth of nine feet, and transportation will be interrupted only by ice and extreme high water of the winter and spring months.

The Ohio River is 967 miles in length. Originally the proposed system required 54 locks and dams numbered consecutively 1 to 54 from Pittsburg to Cairo, but by some re-locations in the lower river lock and dam number 42 was cut out, leaving a total of 53. The minimum and maximum distances between any two locks and dams is 1.9 miles and 50.4 miles, respectively. In the upper 483 miles of river there are 37 locks and dams and 16 in the lower 483 miles, these varying distances being due to the natural channel differences between the upper and lower parts of the river.

The locks of the entire system are of the same size, 100 feet by 600 feet, and constructed on the same general plan. They are placed so that the land wall is at the foot of the bank nearer the natural river channel. The lift is between 6 and 9 feet in all cases, except lock number 1 which is 3 feet, and lock number 41 in the Louisville and Portland canal which is 28.2 feet, and lock number 54, which is 12 feet. Both the river and land walls of the locks are built of plain concrete, the land wall extending 600 feet above the upper end of the lock and 600 feet below the lower end of the lock to serve as a guide on entering the lock chamber and protecting the channel from the bank erosion. The river wall contains the valves that fill and empty the lock, also on the outside of the river wall at the center of the chamber is built in a small turbine pit in which is installed a turbine that furnishes power to open and close the gates and valves.

The lock gates being used are of the rolling and miter types. Due to the width of the lock and low lift and also a saving in length of the lock walls it was at first thought more economical to use the rolling type, but due to the cost of keeping this type in repair and difficulties of operating when not in perfect condition the miter type is being used in the later designs.

The dams are all of the movable type, that is, they fold down in the bed of the river when the stage is sufficient to give a nine foot channel depth, and do not have any effect on the stage when this condition exists. They extend across the river at right angles to the river wall at the center of the lock chambers in all cases except at the Louisville and Portland canal. The typical dam, in the upper river, is made up of a navigable pass, bear traps, and chanoine weir, in the lower river the bear traps are omitted and where the river is wide a section of fixed weir is added next to the bank opposite the lock chamber. The navigable pass in all cases is between 600 feet and 800 feet in length and is made up of chanoine wickets which in all cases are between the lengths of 12 feet and 18 feet. The elevation of the pass sill is near the elevation of the normal river bed. The standard bear trap is in two sections each 91 feet in length separated by piers, the sill being near the same elevation as the pass sill. They are of the two and three leaf type, the two leaf type being found to give the more satisfactory results. The principle use of the bear traps is to hold the proper head during the raising and lowering of the chanoine wickets, the rises being more gradual in the lower river, their use is found to be unnecessary. The chanoine weir differs only from the navigable pass in that the sill is about 5 feet higher and the wickets correspondingly shorter. The fixed weir is built of plain concrete and corresponds in section to the usual fixed dam.

Where practicable the foundations for the lock walls and dam are laid on solid rock, and where sand, gravel, and earth extend to great depths the foundations are entirely on piles, protected by sheet piles and riprap. Practically all of the masonry work is plain concrete.

The lock gates and valves are operated by compressed air supplied from storage tanks housed in a brick power house on top of the bank near the lock chamber. The compressed air is furnished from the turbine in the pit on the outside of the river wall or from the auxiliary steam plant installed in the power house.

A lock keeper is stationed at each of the completed dams. He has under his charge a force of men sufficient for operating the lock gates, raising and lowering the wickets, maintenance and general repairs. Lockages are made at all times free of charge for any passing boat. The employees are given quarters in permanent houses, 2 to 4 in number, which have been constructed and are maintained by the government for this purpose.

In most cases the construction of a lock and dam is let in one general contract except some of the movable parts and machinery. In some cases contractors have either refused to bid or their bids have been excessive, due to the unreliability of the seasons and character of the foundation material, in which case the government is doing the work by hired labor. The construction season is variable usually being from June to December with occasional freshets which always entail a loss of time and often great losses of material and uncompleted work. The average time of construction is four years.

Beginning at the source of the Ohio 46 miles of the project have been completed, and when all work is done that is now under construction 202 miles will be completed, and when the entire project is completed there will be open to traffic 967 miles of river with a minimum channel depth of 9 feet.

Lock and dams numbers 1, 2, 3, 4, 5, 6, 7, 8, 11, 13, 18, 19, 24, 36, 37 and 41 are constructed, numbers 9, 10, 12, 14, 15, 16, 17, 20, 26, 28, 29, 31, 35, 39, 43 and 48 are under construction and numbers 21, 22, 23, 25, 27, 30, 32, 33, 34, 38, 40, 44, 45, 46, 47, 49, 50, 51, 52, 53, and 54 are to be constructed. Lock number 41 in the Louisville and Portland canal was constructed 80 feet wide; it is at present being widened to 110 feet.

Lock and dams numbers 1 to 10, inclusive, are being constructed from the United States Engineer's office at Pittsburg; numbers 11 to 30, inclusive, from the United States Engineer's office at Wheeling; numbers 31 to 40, inclusive, from the United States Engineer's office at Cincinnati; numbers 41 to 54, inclusive, from the United States Engineer's office at Louisville.

THE FALL CREEK BOULEVARD

By A. A. Smock, C. E., '12

Fall Creek is a tributary of White River into which it flows at a point about one and one-half miles northwest of the center of Indianapolis. It is from one hundred to one hundred and fifty feet wide on an average at low water, although it, of course, widens out at numerous places. Except for a few deep holes in its bed where gravel has been excavated, it is very shallow and has numerous sand bars along its course.

It enters the City of Indianapolis at a point near the northeast city limits and flows southward and westward through the city, for about six miles, approximately half of which is through desirable residence district.

The creek bed has shifted toward the south in the past, and along practically its entire southern side there is a well defined bank varying from ten to twenty feet in height. The northern bank as a rule is quite low and there is a strip of low ground all along this bank that is subject to overflow when the creek rises abnormally, as it does every few years.

The Board of Park Commissioners of the City of Indianapolis have full control of the stream and its banks, and a system of boulevards on both sides of the stream is being worked out. These boulevards are a great benefit in more ways than one. Primarily, they protect the adjacent property, as the roadways are built upon embankments high enough to withstand any flood likely to occur. These embankments are laid out carefully, in long graceful curves and in some places they are two hundred feet from the water line, leaving a space between the driveway and the water for a park. Several sections of the boulevard have been completed for a number of years and they have increased the appearance of the neighborhood very much. They are lined with fine residences, apartments and other high class buildings, which would never have been built along an unsightly creek bank. Other sections of the system have been partly completed by the erection of the embankment and the building of temporary gravel drives, to be replaced later with pavement or macadam surfaces. These sections, offering as they do, a safe protection from high water, have given rise to the building of countless homes upon ground which was formerly left alone because it was low and subject to overflow.

The last two sections of the north drive are now being built. One begins at the Fairgrounds bridge at Thirty-eighth Street and runs southwest to Thirtieth Street. From this point to Northwestern Avenue, about two miles, the drive is complete. From Northwestern Avenue, west to the Big Four Railroad, is a section twenty-six hundred feet long that is being constructed under the writer's supervision.

This section is through a part of the city that has never been considered valuable. The ground for some distance north of the creek is very low and has been used as a dumping ground for many years. The embankment varies in height from five to sixteen feet, and when completed will be from two to four feet above the high water mark of the 1913 flood. The embankment is eighty-five feet wide, with a slope of four or five to one on the stream side, and natural slope on the property side. The four to one slope is composed of whatever soil was obtainable, to provide for future planting of trees and shrubbery.

There are two distinct steps in the construction of the embankment. The first step is the formation of the four to one slope with a top width of about five feet, using all the soil that is on the ground in the lines of the boulevard. The second step is the gradual widening of the top of the fill to its final width of eighty-five feet, using gravel which is taken from the creek bed. The excavation of this gravel thus straightens and deepens the channel of the creek. The design calls for a waterway of about four thousand square feet below the high water mark.

The excavation required to widen and deepen the channel is nearly two hundred thousand yards, about one-half of which is used in the embankment, the remainder becoming the property of the contractor at a stipulated price. As it is nearly all fine sand and gravel, it is washed and prepared for the local street and building work.

Work was commenced in August, 1913, and the four to one slope of soil was completed by January 1, 1914. The remainder of the embankment was complete by May 1st, and since then the entire output of the excavator has gone into the gravel plant. The excavating is done with a Monighan drag-line excavator, a large machine consisting of an upper rotating part mounted on wheels which revolve on an eighteen foot circular track. The base is twenty-four feet square and rests on rollers and heavy planks. The boom is sixty feet long and the bucket is of the Page type scraper bucket, two cubic yards capacity. This machine travels ahead of its work, instead of behind it like a steam shovel does. It was erected at one end of the boulevard and the first thing done was to strip off all the soil it could reach and dump it in the four to one slope on the stream side of the embankment. The excavation was at the average of four or five hundred yards per shift. The machine moved forward thirty to fifty yards per day, according to the height of the fill, leaving behind it an irregular ditch from which the earth was taken and a regular pile of earth in its final place. Then the machine was moved over to the water's edge preparatory to removing a sand bar. This bar was about three hundred feet across and roughly circular. The water flowed around it, making an island of it. The machine was gradually worked down to the water's edge, where it dug for itself enough earth to make a fill wide enough and high enough for it to run upon. Following the machine came a track gang, laying three foot track along the top of the soil previously thrown up, and when the excavator was in position to begin the removal of the sand bar, two dinky locomotives, each with six two-yard cars were used. The bucket on the machine just fills one car, and it was found that two engines could keep the machine busy under ordinary conditions. A train of six cars is filled in about ten minutes as an average, and in the three or four minutes delay while one train gets away and the other one gets in place for loading, the operator of the machine must excavate and throw ahead enough material that the ground men can level up and lay their planking ready for the next forward move of the machine. It is necessary to plan ahead in using these excavators, for they cannot turn in a small space, and considerable difficulty was experienced in working out the manner of the cuts back and forth of this sand bar. One great advantage of this machine is its ability to make its own fill, hence it can go almost any place. On this job it has filled its way across the creek four times, two times when the entire creek was dammed up, and it was necessary to move about thirty feet and then reach out behind and remove the fill to let the water through, using the material thus removed to lengthen the fill ahead.

While removing this sand bar, the dump track was about eighteen hundred feet long, and was continuous except for one switch. The track ran along the top of the embankment and had a switch located so there would be a two per cent.

grade down to the level of the ground at the machine. This machine was then at the extreme end of the work, and as the work progressed it was necessary to take up track, finally when the bar was entirely removed the excavator moved along the bank of the creek, cleaning up behind itself and leaving a comparatively smooth bank which required only a little hand trimming.

At one point in the work was the double outlet of two concrete storm sewers. This was an unsightly structure. On account of the low grade of the sewers and the surrounding territory, the flow lines were only a foot or so above low water, and the tops projected out of ground nearly ten feet. It was decided to submerge the outlets of these sewers and the excavator was used to remove about fifty feet of the concrete. The scraper bucket was taken off and a fifteen hundred pound drop hammer put on to break up the concrete. The immense power of the engines was very useful in handling the broken concrete. After the sewers were demolished, the bucket was put back, the machine reached out behind itself, dug enough dirt to fill in the holes where the sewers had been, and passed on.

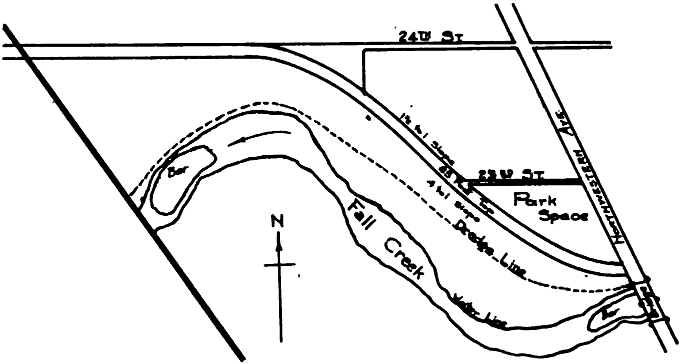


Fig. 1

From this point for the remaining twelve or fifteen hundred feet, the boulevard was from one to three hundred feet from the bed of the stream, and all the intervening material was to be removed, in order to widen the creek. It was deemed advisable to also clean up the part of the channel where the water was running, at an average depth of about three feet. The width of the water was about one hundred feet, so it was necessary to work the machine out into the creek forty feet, so the bucket could reach to the further side of the stream. The dump track was relaid and the switch placed at the east end on top, from which the track ran west down a one and one-half per cent. grade for eight hundred feet, where another switch was placed, the track again running east to the machine, which was about two feet above the water level. The track was floated, that is, temporary, and moved daily, to keep it always the proper distance from the machine, which was steadily moving upstream, making its own fill and cleaning up the channel to the side and rear for a total width of about one hundred feet. After moving forward about eight hundred feet, it was again necessary to cross the creek to clean out a sand bar, after which the machine came back on a second cut through. A third cut will be required to finish the work.

The operation of the work is carried on by three distinct gangs—the machine men, dinky men, and dump gang. The machine is operated by one engineer and a fireman, with two ground men. There are two men used at the point where cars are loaded to clean up the gravel that spills out of the bucket. There are two dinkies with an engineer and brakeman, and six men as a rule in the dump gang. In addition there are two men who are kept busy on track work, repairing, tamping, straightening, etc., two teams hauling coal and supplies, a blacksmith and helper repairing cars, the breakage of which is very great, a foreman and a timekeeper are always on the work. Since the embankment was completed and the surplus gravel has become the property of the contractor, there have been about six men employed on the gravel plant. All the foregoing work was carried on day and night until January 1, 1915, when the extreme cold weather caused so much delay that it was deemed advisable to shut down for a short time.

The contract is one that will result in unusual economy to the Park Board, as the contractor is required to furnish all material and labor and the necessary machinery, and is paid the actual cost plus a percentage with a fixed limit as to the unit cost. All surplus gravel is paid for by him, and this one item will repay the Park Board nearly one-third of the contract amount.

NOTES ON THE CONSTRUCTION OF A 48-INCH REINFORCED CONCRETE SEWER

By ALBERT A. CHENOWETH, C. E., '15
JR. W. S. E.

The city of Muskogee, Oklahoma, had at the time of the construction of its main outfall sewer a population of about 30,000. The town is so situated that the drainage is easily accomplished. About three-fourths of the area within the city limits slopes directly south towards Coody's Creek, the remainder falling off toward the northeast. Coody's Creek, a small stream having its source in the southwest part of the town was being used to provide a means of sewage disposal. As the population was rapidly increasing the need of an outfall sewer was recognized, one that would carry the sewage entirely away from the city, at least as far as the Arkansas River, a distance of seven miles. Mr. Alexander Potter, of New York, who was retained as engineer finished the plans in May, 1911, at which time the contract was let, for 10.63 miles of sewer, varying from 48″ to 18″ in diameter, the pipes to be of concrete and vitrified tile.

The job was well under way by the first of June. The writer was employed as resident engineer on the four sections to be built of 48″ reinforced concrete pipe, a total length of 20,700 feet. The making of such an amount of reinforced concrete pipe at an average distance of six miles from a railroad involved transportation questions of some magnitude. Other branches of municipal and private construction commanded all available teams, since the larger amount of such work was in the city itself. To offset this the contractor decided to use a steam tractor, which could easily haul six 3-yard cars. This train made three 6-mile-average trips in an eight hour day, a total of 36 miles over ungraded earth roads. Usually cement, sand and gravel were hauled in about the proportions to be used each day, thus enabling the contractor to keep his pipe making gang at work steadily. The cement was tested by the city chemist according to standard specifications, he reporting the result of the seven day test to the contractor, the engineer and the City Engineer's office simultaneously. The forms used were patented, their cost being payment of a royalty of $1.20 per lineal foot of finished work. Only 150′ were available, necessitating a careful watch that the contractor, in his zeal to push the work ahead, should not remove the forms too soon, thus risking the safety of the pipe. Under the warm southern sun, the minimum time of removal was five hours, allowing the pouring of about 270′ of pipe each eight hour day. A 1 :6 mixture was used, always made very wet, so that it could be churned well, thus giving against the oiled steel forms a very smooth finish. The oil used permitted of easy and safe removal of the forms. The reinforcement used was a standard mesh, 1/4″ circumferential bars, tied together at 3″ intervals with No. 14 wire. A great deal of trouble was experienced in making the laborers keep the reinforcement in place, but after some time a few men learned to do it very well. In freezing weather the danger of frosted concrete arose. To obviate this a crude oil lamp was kept burning in each pipe for 30 hours after pouring, and in addition large brush fires were kept burning throughout the pipe yard. The water used in mixing was also heated, but in spite of these precautions some of the pipes showed marks of frost. Those so marked were found to be fairly sound when examined the next spring after a winter above ground. The pipe making by great effort was kept ahead of the trenching, which on account of the soil encountered was not done very rapidly.

The heavier work of trench excavation was done by a Marion shovel, mounted on four trussed beams, which were carried on rollers on either bank of the trench. It was possible to dig a maximum of 17′ with this machine, and in case slightly greater depth was required the remainder was thrown ahead with hand shovels into the face of the cutting. Excessive vibration under the action of the shovel loosened the earth of the trench walls and necessitated careful bracing in material that would probably otherwise have required none. The work under the shovel was braced as shown in Fig. 2. Quite the largest amount of the sewer lay at a less depth than the most economical working depth for the shovel, so a Municipal Excavator was used in addition. This machine cut a regular, smooth-sided trench, 66″ wide. Its most economical depth was 9′ while the shovel did best in a 15′ trench. The trench dug by the excavator in general required but very little bracing; the pipe laying also followed closely, the bottom of the ditch being well graded by the machine.

The greatest difficulty found in laying the pipe was in trying to get a reasonably smooth joint. After a few hundred feet had been laboriously tamped into a firm bearing, the suggestion of a 2″ x 12″ plank to be laid continuously in the bottom of the trench on the centre-line was eagerly adopted and worked wonders in saving labor and securing better joints. The trench in all cases was excavated to a square bottom. This made necessary very careful watching to prevent a chance of the failure of the pipe to carry its load of back-filled earth, through a lack of solid support in its lower half. The sewer was laid on a grillage of specially shaped heavy timbers in soft wet ground or in cuts of less than four feet, the amount of the latter being some 400′. It was in the shallow trench that the men worked up their greatest speed; 416′ being by long odds the best eight hours' work.

Wages paid were as high and in certain cases higher than in the city, both to the laborers and foremen, yet the job was nearly always short-handed, and a change of foreman for a gang was as likely to come each month as not. Under such conditions the work slowly forged ahead, reaching completion before a year had passed.

ROPE TRANSMISSION

By E. M. Carver, M. E., '09

The following brief discussion of rope transmission is no way intended to be an exhaustive or adequate treatise on this very interesting subject, yet many engineers well versed in other types of drives have a signally limited amount of information concerning the extension and scope of rope driving. The writer has thought that the description of a few typical drives would prove of interest and possibly give the uninitiated an insight into the almost universal manner in which this very flexible type of transmission is applicable, not only to the conditions of perfect simplicity, but also to the requirements of the most intricate and complicated character.

The introduction of ropes for the mechanical transmission of power is commonly accredited to C. F. Hirn, of Logleback on the Rhine, who in 1852 conceived the idea that by converting power into the highest practicable velocity of the transmitting organ, the size and weight of that organ might be reduced to minimum dimensions, and its length therefore extended indefinitely, its velocity being reconverted into power at the operative point.

The adaptability of ropes to do the work of belts, without the limitations of the latter, was soon recognized and in England they immediately began to be applied for main drives as substitutes for very heavy, long, and expensive belts. By the multiplication of single rope belts running in grooved wheels, larger powers may be delivered, but the aggregation of single ropes carries limitations which confine its usefulness to comparatively narrow bounds. It is impossible to secure uniform length for several independent ropes since the stretch cannot be controlled and it is impracticable to apply tension devices separately to a number of ropes running so close together. Hence to obtain adhesion to the wheels and thereby secure tractive force it becomes necessary to use large heavy ropes in pinch grooves which must be deep and spaced far apart to prevent the ropes from jumping and fouling each other.

The principal advantage of the English system is that although one or two of the ropes may break it does not materially affect the drive, yet when these loops are replaced, the new rope rides higher in the pinch groove, since the old ropes having been under working strain are worn and have been stretched to a smaller diameter. In drives where the sheaves are of unequal diameter this condition causes a differential of pitch diameters which is certain to cause a change of speed and slippage in the grooves. Therefore, for the successful installation of an English drive it is essential that the driving and driven shafts shall both be horizontal, not far from the same level, and at a considerable distance apart. Under these favorable conditions the English system is efficient and economical, but its application is limited for obvious reasons.

This in brief was the condition of power transmission by ropes in 1883, when Wallace H. Dodge, founder of the Dodge Manufacturing Company, proposed to employ a single endless rope in multiple wraps, and to apply thereto a proper tension device; and thus at one stroke overcome the former limitations and make the rope drive universally applicable for all transmission purposes, regardless of distance and direction. This later type of drive is called the American system, one continuous endless rope is used, winding around the sheaves successively in the several grooves, making as many complete wraps as may be required by the power transmitted. From the last groove on the driving sheave the rope passes over single-groove tension and winder idlers which combine to give the rope fair lead to the first groove of the driven and also to control and regulate the tension in the ropes throughout the drive. The weighted tension carriage can be made to give just the right amount of tension which may be required to accommodate changing conditions by manipulation of the weights used.

Thus rope driving passed through its experimental stage and in 1885 when the American system was patented, drives of this type soon made their appearance, as in its new perfected form, all haphazard elements had been eliminated and it was possible to intelligently design a drive suitable for the work it had to do.

Designers of rope drives early discovered that it was absolutely necessary to give especial attention to sheaves in regard to diameters, groove forms, accuracy, balance and true running.

Rope wear is greatly increased by the use of small sheaves. The frequent bending and then straightening of the rope, in running onto the sheaves and off again, is a continuous performance, and excessive degrees of such bending must be avoided if the rope is to have a fair length of life. The wear of the rope is both internal and external. The internal is caused by the sliding movement of the fibres on each other while bending around the sheaves, the external by the slippage in the grooves of the sheaves. This wearing is assumed to be directly proportional to the speed. Moderate bending is not particularly injurious, but beyond certain limits the action grows rapidly worse. Experience has proven that good Manila transmission rope may be satisfactorily worked on sheaves with diameters as small as 40 times the rope diameter, but the durability of the rope will be increased if 50 or 60 diameter sheaves are used.

The 60 degree groove is used for the driving and driven sheaves in the American system and while being efficient in operation, it gives at the same time a minimum of rim width and thickness which means economy of space and provides a light and inexpensive sheave. Idler sheaves have U grooves if the ropes have sufficient arc of contact to insure no slippage. In the U groove the bottom radius is made the same as the rope itself; this holds the rope central and allows the rope to enter and leave the sheave free and clear, without chafing.

Especial attention in regard to accuracy and uniformity of all grooves is absolutely essential to perfect success. The pitch diameter must be exactly the same for each groove as the slightest differential will produce variation in the rope speed and cause change of tension or slippage which will immediately be reflected in the operation of the drive and produce undue wear on the rope.

The breaking strain of first-class Manila transmission rope may be taken as 9000 x dia.^2 and for continuous service, practice has shown that to give long life it is not advisable to work the rope with a tension of over $^1/_{50}$ or 2% of the breaking strain, therefore, $\frac{9000}{50}\,\text{dia.}^2 = 180\,\text{dia.}^2$ which is the maximum allowable working tension.

There is quite a difference of opinion among experts as to the proper method of figuring the H. P. of ropes. The differences arise over the question of centrifugal force and what has been termed "adhesive tension." The following formula has been used by the Dodge Manufacturing Company for several years and experience has proven it to be entirely satisfactory for the American system:

$$\text{H. P.} = \frac{(T - Wv^2)}{Rg} \times \frac{V}{33000}$$

T = Working Tension or 2% of Ultimate Strength.
W = Weight of rope per ft. = $.34\,D^2$
D = Dia. of rope in inches.
R = Radius of sheave in feet.
g = 32.2
v = Velocity in feet per second.
V = Velocity in feet per minute.
9000 dia.^{2} = Ultimate Strength.

The following table is based upon the above formula all sheave diameters being 40 diameters of the rope.

Rope Diam.	Min. Diam. Sheave	**Horse Power of One Rope at Different Speeds on Sheaves of Minimum Advisable Diameters**											
		500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
¾	30	1.5	3.0	4.5	5.8	7.1	8.1	9.0	9.7	10.2	10.4	10.3	9.8
⅞	35	2.1	4.1	6.1	8.0	9.7	11.3	12.6	13.7	14.5	15.1	15.2	15.0
1	40	2.7	5.4	8.0	10.5	12.8	14.9	16.8	18.4	19.7	20.6	21.1	21.2
1⅛	45	3.4	6.8	10.2	13.3	16.3	19.1	21.6	23.8	25.6	27.0	28.0	28.5
1¼	50	4.3	8.5	12.6	16.5	20.3	23.8	27.0	29.8	32.3	34.3	35.8	36.8
1⅜	55	5.2	10.2	15.2	20.0	24.6	29.0	33.0	36.6	39.7	42.4	44.6	46.1
1½	60	6.1	12.2	18.1	23.9	29.4	34.6	39.5	43.9	47.9	51.3	54.1	56.2
1⅝	65	7.2	14.3	21.3	28.1	34.7	40.9	46.7	52.1	56.9	61.1	64.7	67.6
1¾	70	8.3	16.6	24.7	32.7	40.3	47.6	54.5	60.8	66.7	71.9	76.4	80.1
2	80	10.9	21.7	32.4	42.8	52.9	62.6	71.8	80.4	88.5	95.7	102.2	107.8

Straight open drives of simple design are admirably illustrated in Figs. 1, 2, 3, 4 and 5. Fig. 1 shows a 1000 H. P. motor drive at the Niagara Falls Hyd. P. & M. Company, Niagara, Falls, N. Y.

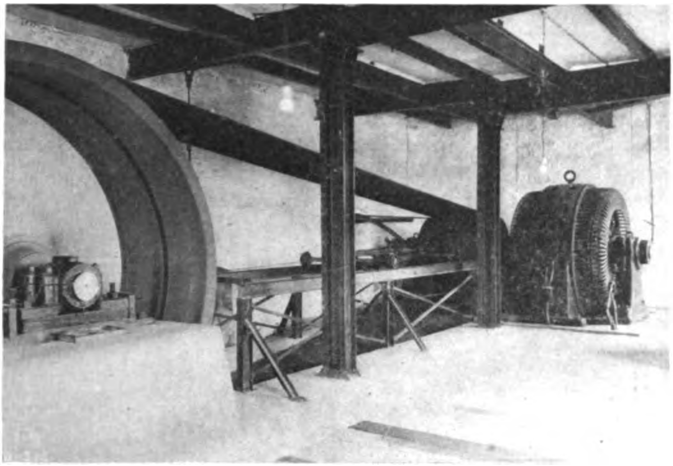


Fig. 1.

Figs. 2 and 3 show two 1500 H. P. drives from a 3000 H. P. engine at the Barrett Manufacturing Company, Peoria, Illinois, each of these drives having 25 wraps of 2-inch rope.

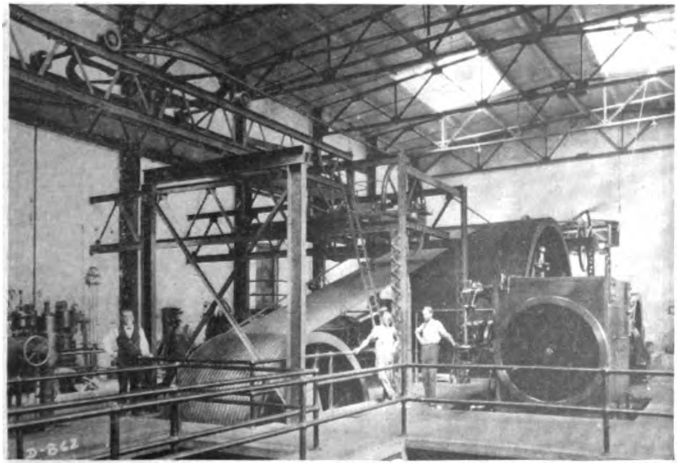


Fig. 2
3000 H. P. Engine Showing one of two 1,500 H. P. Rope Drives.

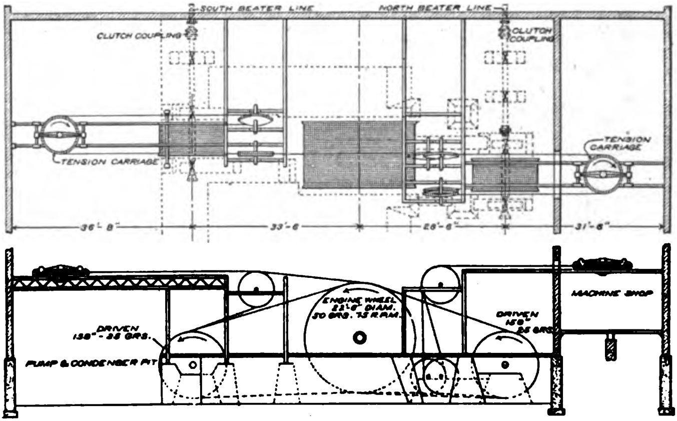


Fig. 3.

Plan and Elevation of Above Drives.

An extremely compact drive at the Diamond Rubber Company's plant, Akron, Ohio, is shown in Fig. 4. Note the arrangement of the tension carriage, it being placed in the basement.

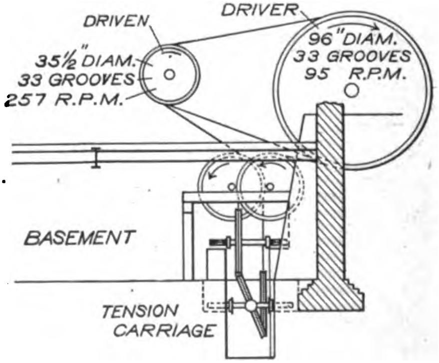


Fig. 4.

An Extremely Compact Drive.

The Mechanical Rubber Company of Cleveland, Ohio, also have a drive (Fig. 5) which illustrates the short center proposition and shows how the tension equipment may be located at any convenient point.

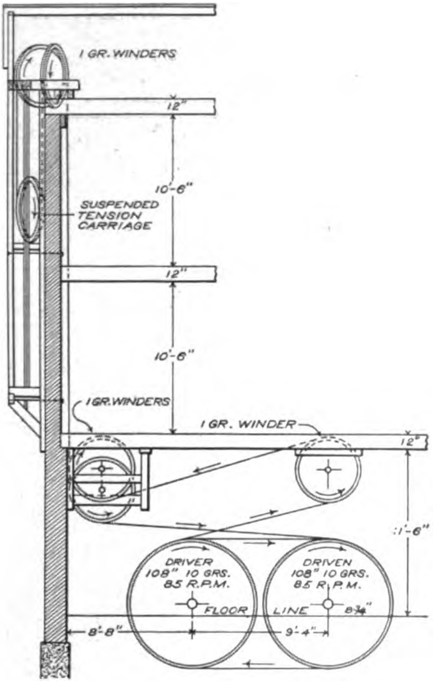


Fig. 5.

Mechanical Rubber Co., Cleveland, O.

For the heavy drives it is often desirable to mount either the driving or receiving sheave on a clutch quill (Fig. 6). When the clutch is out the quill rests motionless in its own bearings, and thus all transmission losses are eliminated. This arrangement makes a very flexible drive and as the quill takes care of the bending stresses due to the tension in the ropes and the weight of the sheave, the shaft need not be in excess of that required to transmit the power.

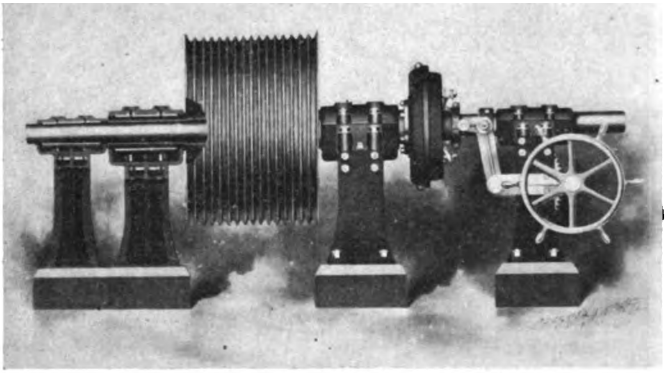


Fig. 6.

A Typical Quill Unit for a Rope Drive.

Connecting shafts need not be parallel as by altering the form of grooves and introducing idlers, it is possible to accommodate any angle or difference in elevation that may be encountered (Figs. 7 and 8).

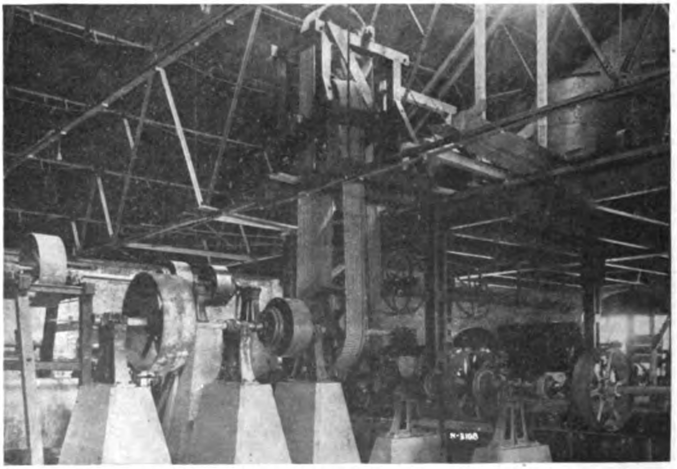


Fig. 7.

Connecting Two Main Lines at Right Angles.

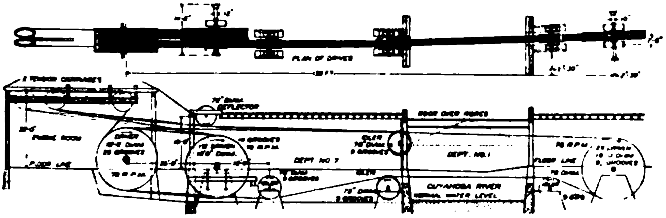


Fig. 8.

Connecting Two Line Shafts not quite Parallel.

Transmission of power to detached buildings or isolated shafts may readily be accomplished as shown in Figs. 9 and 10.

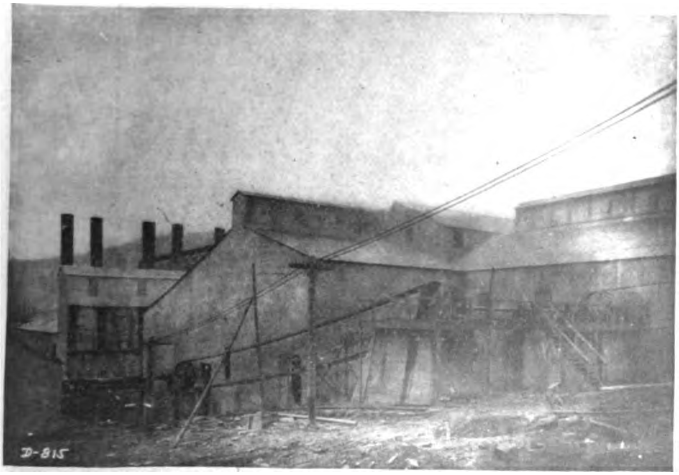


Fig. 9.

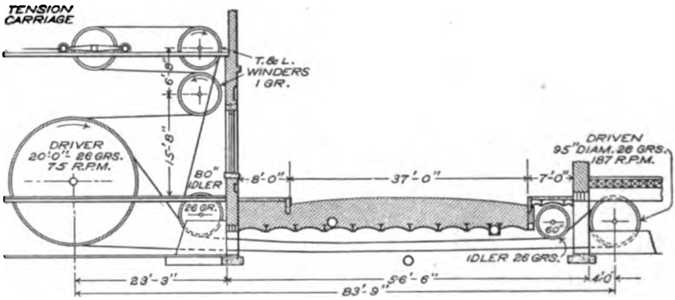


Fig. 10.

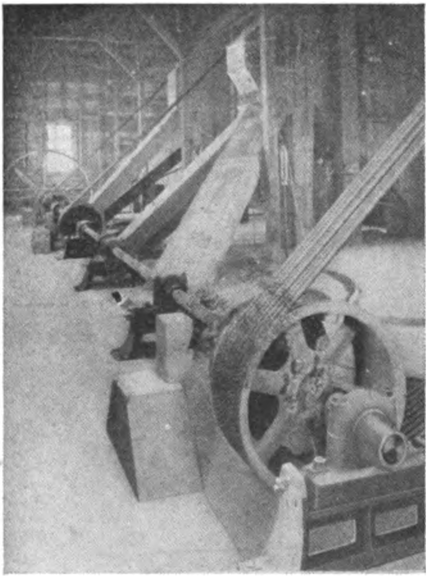


Fig. 11

Reverse Drive for Elevator Counter Shaft

Reversal of motion is taken care of by either crossed ropes or by the use of reversing idlers. Figs. 11, 12 and 13 show typical illustrations.

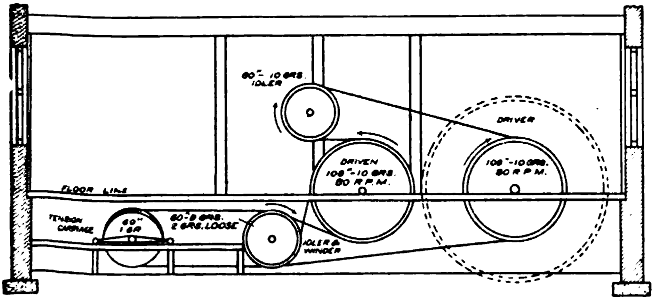


Fig. 12

Reversal of Motion on Short Centers

Drop-off drives from a main or driving shaft to receiving shafts on the several floors of a building are shown in Fig. 14. These drives are made extremely flexible by the use of clutches on each shaft.

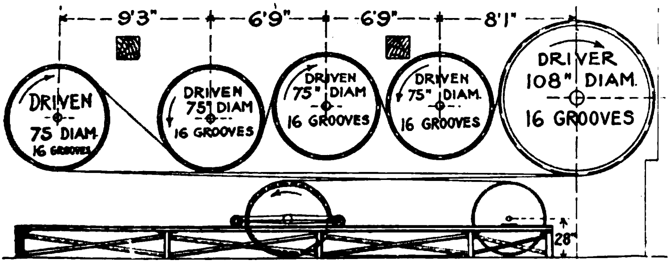


Fig. 13

Simple and Compact Arrangement of a Drive

Fig. 15 illustrates another drop-off drive in the Arnold Print Works, North Adams, Mass.; here 20 lines are driven from the main driving shaft, in relays of 10 ropes each. From the 20 Gr. main driver 400 H. P. is transmitted, dropping off one wrap at each of the first nine shafts; 11 wraps drive the tenth shaft, which is the relay point for the second drive of 10 wraps or 200 H. P. from here the drop-off continues to the last shaft which has only one rope.

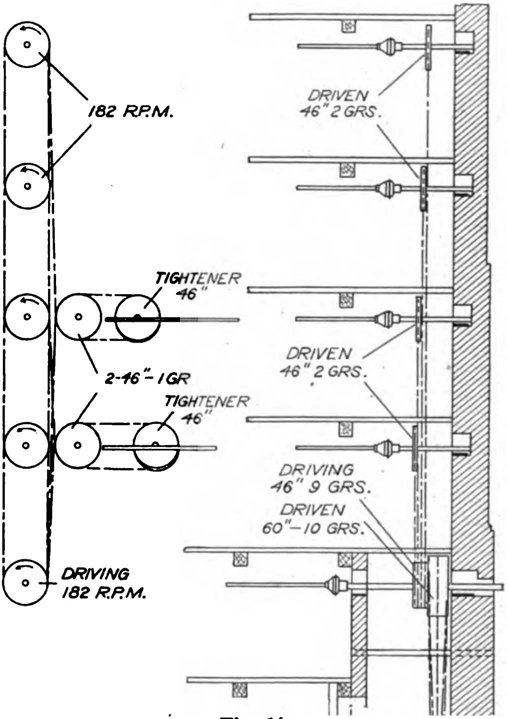


Fig. 14.

Typical Drop-off Drive.

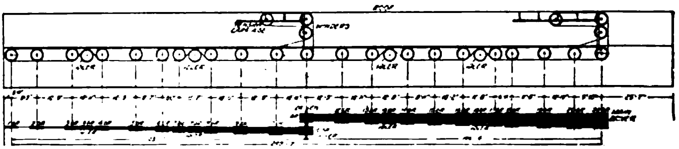


Fig. 15.

Each Shaft Driven Directly from the Main or Relay Line.

ONE PROBLEM IN THE SCOTT-CONNECTION OF TRANSFORMERS

By E. A. Bureau, E. E., '15

(Note:—This article is based on a thesis prepared by B. N. Das Gupta, '14, and the author, with the assistance and guidance of Professor Rowell of the School of Electrical Engineering.)

When it is desired to obtain two phase power from a three phase source, it is customary to use the Scott scheme of connecting the transformers. Two transformers are used, one having an 86.6% tap and the other a 50% tap, the connections being made as shown in Fig. 1. Fig. 2 shows the vector relation of the supply voltage as applied to the transformer primaries, the dotted lines indicating the primaries. The vector relation of the secondary voltages are shown in Fig. 3.

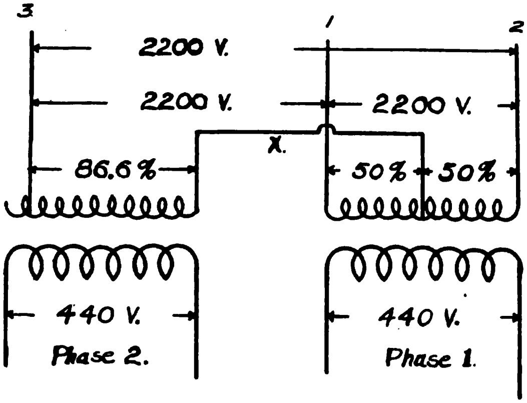


Fig. 1. Connections of 2.5 Kw. Transformers.

Theoretically, the voltage relations shown are correct and proper, and produce the desired result. Practically, the scheme does not always work so well under load conditions. A transformer bank, which is at this time still in use in the

Purdue Electrical Engineering Laboratory, demonstrates very well this failure to fulfill theoretical expectations. This bank consists of two 2.5 Kw. transformers, 2200, 1900-440 volts, Scott-connected. It has for its load a motor generator set consisting of a 5 hp., 5.5 ampere, Bullock two phase motor, direct connected to a Bullock d.c. generator. This combination has never been satisfactory because of the bad unbalancing of voltages in the two secondary phases. Tests at different loads brought out the characteristics shown in Fig. 4. (In referring to Phase 1 and Phase 2, the same notation will be used as is designated in Fig. 1.) The voltage in Phase 2 holds up very well, which makes the resultant regulation comparatively small. However, in Phase 1 there is very bad regulation, even with that phase taking only 60% as much current as Phase 2.

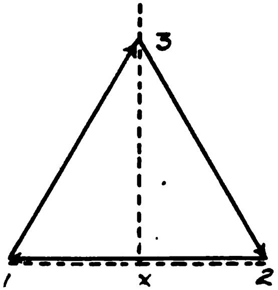


Fig. 2

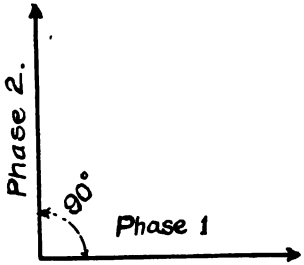


Fig. 3

Poor regulation of a transformer means essentially a large drop of voltage in the transformer, which means voltage loss in its impedance. This impedance drop can be resolved into two components: one, an IR drop in the coil, in phase with I; and the other, the reactive drop at right angles to I. This reactive drop consists of a counter e. m. f. set up by the leakage flux of the transformer coils—the flux of each coil which does not link any other. As a test of the above statements, regular impedance measurements were made on the two phases. As the secondaries were short circuited in turn, voltage was applied to the primary side, At about 60% full load current an impedance drop of 60 volts was measured on Phase 2. On Phase 1, for the same current, the impedance drop across the whole phase (points 1, 2 to 3) was found to be 220 volts. Only 38 volts of this drop was in the part 3-x. The large balance of about 180 volts was therefore practically all leakage reactance drop, since only about 6 volts represented the equivalent IR drop of the transformer as tested.

When a current is sent through a coil, a magnetic field is set up; and, when this coil surrounds one leg of a closed magnetic circuit, most of the lines of force are concentrated in the iron. However, there is some of the flux which takes a part iron, part air path. This is known as leakage flux, since it "leaks" out of the iron path. If a second coil is placed on the iron core, the whole constitutes a transformer. The coil upon which the voltage is applied, is called the primary; and the other, the secondary. When an alternating current is sent through the primary, an electromotive force is generated in the secondary; and this e.m.f. applied to a load, forces through the secondary a current which, according to Lenz's law, sets up a counter m.m.f. and thus opposes the flow of flux due to the primary. This counter m.m.f., which is proportional to the load, produces additional leakage of flux from the primary coil by forcing out, into the air around the secondary, part of the flux that has threaded the iron through the primary. If it were possible to wind the two coils so that they would occupy the same space, their values of m.m.f. would be coincident through-

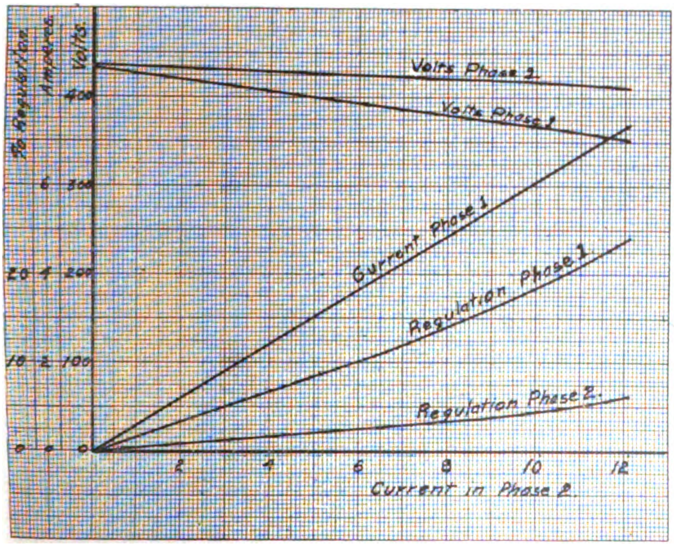


Fig. 4

out but opposite, giving, as a result, no net leakage. Thus the leakage reactance becomes a measure of the magnetic separation of the coils, for the resultant leakage flux is dependent upon the distance between the coils. To illustrate the above statements, tests were made on three different styles of transformers in order to determine the relation between the magnetic separation of two coils and the amount of leakage flux. These transformers were: a Moloney core-type transformer with four coils, two on each leg; a Wood shell-type transformer with sandwiched coils; and a special design Duncan core-type transformer with four concentric coils, each of which were equally distributed about the two legs of the transformer. With the Moloney transformer it was found that between coils on the same leg, with full load current in the coils, the leakage reactance voltage was comparatively small, being only 2% or 3% of rated voltage, but that between coils on different legs this value increased to nearly 20%. In the Wood transformer a like relation was found: the farther apart the coils, the greater the per cent. of leakage reactance. The leakage reactance between any two coils did not exceed 5.8%, and was as low as 0.8% for coils close together. On the Duncan transformer equally good results were obtained. In this case the reactance drops varied between 0.4% and 2%, being directly proportional to the amount of magnetic separation of each pair of coils tested.

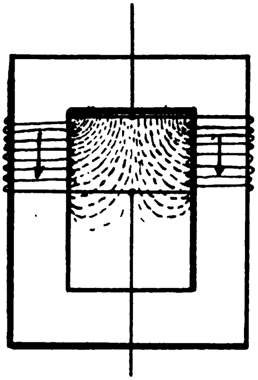


Fig. 5

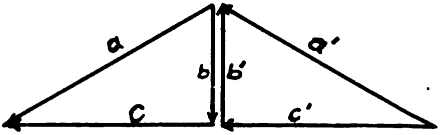


Fig 6

Considering again the results of the tests on the 2.5 Kw. transformer of Phase 1, with the primary coils connected as in normal single phase operation, the impedance drop is only 5% of the rated voltage, while with the Scott connection the impedance drop is nearly 25% of the rated voltage. In view of what has been said in the preceding paragraphs this difference of impedance drop is now easily explained. In normal single phase operation the two parts of the primary are acting in such a way that the m.m.fs. generated by each part go through the iron circuit in the same direction. At the same time the secondaries are placed comparatively close to the primary coils, thus insuring a fairly close magnetic relation between the interacting coils. In the Scott-connection impedance test the two primary coils are energized in such a way that the m.m.fs. of the two primaries buck each other. Therefore no e.m.f is generated in the secondaries because no flux passes through the iron circuit. However, this does not prevent a large quantity of flux from passing through the air (Fig. 5) and thus causing a high reactance voltage drop. In the actual operation of Phase 1 of a Scott connection the two parts of the primary are energized, not by currents of the same phase relation, but by currents of 120 degrees separation. The result is an m.m.f. vector relation in the iron circuit, as shown in Fig. 6. The vectors a and a′ represent the m.m.f. set up by the two primary coils respectively; b, c and b′, c′ represent the corresponding components. The "in phase" components send through the magnetic circuit that flux which generates the secondary voltage. Components b and b′, like the m.m.fs. in the impedance test, buck each other,

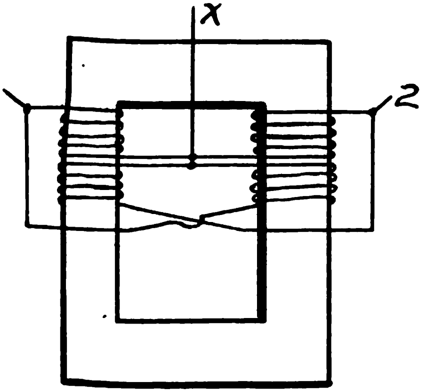


Fig. 7

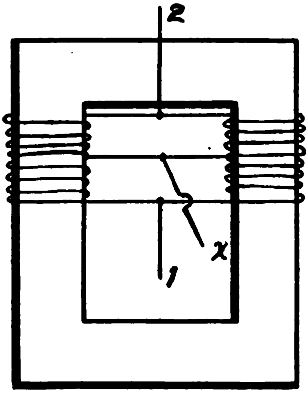


Fig. 8

and are not responsible for any secondary effects, but are the cause of a large amount of leakage flux. The net leakage, thus, is practically all produced by the components b and b′, since the leakage reactance drop, due to components c and c′, is not greater than 5% of the rated voltage. Therefore the natural conclusion is that, in order to diminish the great leakage flux produced by the m.m.f. components b and b′, the two interacting coils, which in this case are the two parts of the primary, must be brought into close magnetic relation.

Since the primaries of the shell-type transformer with sandwiched coils have close magnetic relation, this transformer is a good one to use in a Scott connection. Figs. 7 and 8 show two ways in which the primaries of a core-type transformer may be tapped and connected to give the proper magnetic proximity necessary between the two parts of the primary circuit in Phase 1 of a Scott connection.

In general, it may be said that operating a transformer under conditions which are not normal, may give rise to leakage reactances which are far greater than are popularly supposed to exist. Therefore, when a transformer is expected to be used in special service, it should be designed with subdivided coils, so that close magnetic relation of interacting coils may be obtained.

WINTER SURVEYING IN CANADA.

By A. C. Clarke

The systems of survey in Canada and in the United States have many points of similarity. The general layout of lines with regard to convergence, spacing, and correction and the astronomical references for these lines, resemble each other closely in both countries. In Canada, however, several unusual features are encountered in the field work. The writer feels that perhaps a general description of the surveying operations as carried on in Canada during the winter months will serve to point out some of these distinctive features and will at the same time furnish some idea of the work that is done and the manner of its accomplishment during a season of the year which ordinarily means inactivity to the surveyor in this country.

First, a brief description of the field organization of the Canadian Surveys Department. There are three general divisions of the field engineers. To take them in the order of their work, we have the "base-line" men, the "sub-dividers," and the "resurvey and restoration" surveyors. The "base-line" engineers, as the name implies, are responsible for the "precise" work of the system and it is their especial care to produce, with all accuracy, the reference meridians and the connecting base lines which block out the country and to establish exact monuments for the subsequent work of the "sub-dividers." This second group of engineers are usually contractors running interior section lines on a mileage basis and tying in with a moderate degree of accuracy to the work of the "base-line" men. The third division is made up of those engineers whose duty it is to retrace lost surveys and restore old marks and monuments.

It is obvious that the discovery and restoration of lost monuments would be seriously hampered by cold weather and heavy snows and equally plain that the efficiency of a contractor's party would be materially reduced by the short winter days and the necessity for speed in a snow covered country and with instrument work made difficult by a temperature of 50° below zero. The base-line surveyors, however, have none but their own monuments to heed and carefully precise work is, with them, of far more importance than any mileage record. Winter surveying, then, is confined almost entirely to the work of the base-line operators.

Briefly, the system of survey consists of a number of reference meridians approximately 190 miles apart at the 49th parallel of latitude and converging toward the Pole. The base lines are of 6-mile chord sections, east and west, and are spaced 24 miles apart, numbering toward the north from the 49th parallel as a first base. These lines are marked by iron posts and mounds and pits at every ½-mile station and it is the duty of the surveyor to see that a "sky line" is cut through all timbered country and that well-sized trees are blazed along both sides of the line at intervals of not more than 50 links. It is still further the duty of the base-line engineer to conduct a rough topographical survey of the country for 12 miles on either side of his line, to construct a map from the data so obtained, and to include in his report a description of the soil, watered areas, geology, timber, and animal life within the range of his observations.

The average "base-line" party consists of a chief engineer, two assistants, two chainmen, a picket man and five axemen for the transit party, a rodman for the level work, some three or four "pack horse" men, and a cook and cookee. It is seldom that the party numbers over twenty men.

The summer work differs but little from the surveying carried on along the same lines in this country. Progress is slow, seldom averaging more than four miles per week of actual line. The camp is moved ahead about once a week, each move necessitating the blazing and cutting of new pack trails since base-line work is always far in advance of any settlement.

The arrival of winter, however, causes a number of changes both for the camp and the men. Pack horses are generally superseded during the cold weather by sleighs of various forms since open swamps, rivers, and lakes can be utilized as roads without the necessity of cutting timber. A flat sleigh, 18″ wide by 10′ or 12′ long can be drawn by one horse and will replace the work of a dozen pack ponies and still require less road cutting.

The men adopt a dress very similar to that found in the lumber camps of the northern States—heavy mocassins, mackinaw sox and pants and coats, flannel shirts, heavy sweaters, woolen caps, and woolen mitts with a soft leather covering. Such an outfit furnishes ample warmth provided always that proper drying by the fire at night prevents the donning of damp garments in the morning.

Each tent is provided with a wood-burning camp stove of the collapsible box type and ten minutes of a good pine fire will suffice to heat a properly erected tent to a very comfortable degree. A ten ounce weight of duck furnishes a heat-retaining, wind-proof dwelling place.

The tents are pitched on the ground after the snow has been removed from the site. Guy ropes are fastened to trees felled near the side walls of the tent. The burlap flap around the bottom of the walls is turned out and snow is piled on it to a depth of two or three feet. This serves the double purpose of anchoring the tent and of banking it against the wind. The "floor" of the tent is of spruce boughs piled as thick as the energy or taste of the owners demands. Upon these boughs as a mattress is spread the bedding—usually three pairs of blankets, or perhaps an eiderdown quilt, fastened into a sleeping bag and protected by a waterproofed covering of canvas or light rubber.

Surveying operations continue through the winter months just as in the summer. Progress is, of course, somewhat slower because of the short days and an average of three miles per week is considered good work. It is not unusual to average less than six working hours per day through December and January. The reason for this will be seen when it is understood that daybreak is about 7:30 a. m. and darkness begins again about 4:30 in the afternoon. Deducting from the intervening nine hours at least two for traveling to and from the line and another hour for noon lunch, there is a balance of only six hours for actual work. The difficulty of cutting in frozen timber does not seriously delay the work as this factor is largely compensated for by the fact that the axemen work much harder and more consistently in cold weather.

The instrument men have a number of little problems to solve during the winter's work. Perhaps the first of these is to learn to handle an instrument literally "with gloves." Bare-handed manipulation is out of the question as the metal freezes the flesh almost instantly. Light knitted-silk gloves afford sufficient protection, however, and do not interfere with the careful adjustment of the screws on the instrument. A clouding of the lenses is often caused by a hand or face brought too closely to the glass and tangent screws are sometimes frozen solid as a result of the moisture from the breath of the manipulator.

Observing becomes a real task in cold weather because of the numerous adjustments and readings which have to be taken. In Canada, because of the northerly latitude, Polaris can always be observed during the day with a moderately high power telescope. Night observations are almost never taken. Without the drawback of darkness, the task is still sufficiently exacting, however, when the thermometer is reading at 40 or 50 below zero. Observations for the deflection of the magnetic needle which have to be made at certain hours of the day, depending upon the time of the year, the latitude, and the longitude, do sometimes necessitate night work but the manipulations are short and simple and cause the transitman but little trouble.

The work of chaining suffers no change during the winter months. A five-chain tape is used with a one-chain length following as a check. Corrections are applied for slope with a clinometer and an alcohol thermometer replaces the mercury bulb used in warm weather for the temperature corrections.

Monument building, which consists of the digging of four square pits and the erection of a three-foot pyramid in the center (the iron post being driven at one corner of the pyramid), is, of course, much more laborious work in frozen ground. The number of these monuments to be erected is not large, however, because of the slow rate of progress and it is seldom that this branch of the work delays a forward movement.

The topographical work becomes a real pleasure during the winter months. With no foliage to obstruct the view, snowshoes to facilitate travel, and open water no longer a hindrance, the assistant in charge of the exploring finds himself able to cover a much larger area of country to a distinctly better advantage than in the warmer weather. For these reasons, compass surveys of lakes and rivers are always postponed, if possible, until the cold weather has arrived.

A comparison of the two seasons from a working standpoint brings out, for the base line engineer's consideration, a number of advantages in favor of winter. The ease with which supplies can be transported, and the ability to keep supplies, particularly fresh meats, are alone almost enough to swing the balance in favor of cold weather operations. As a rule, the men are better workers during this season—a fact easily accounted for when one considers the short hours, better food, and the absence of mosquitoes and black flies which make the summer months almost unbearable at times. The rough comforts of the camp are always developed to the highest degree during the winter season and the long hours under cover are frequently used to convert the tent into a semblance of a real home. If we add to these facts the statement that line operations are but little hindered and say, then, that such hindrance is more than counterbalanced by the increased efficiency of the topographical party, it should be plain why the winter months are regarded as the best season for base line work in Canada.

The Purdue Engineering Review

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ORGANIZATION

The Editorial Staff of the *Purdue Engineering Review* has undergone a reorganization. A new Constitution has been adopted by the Engineering Societies, which provides for the different departments of the staff as they now stnad. The electing of only one assistant to each department was made possible by the addition of the Chemical Engineering Society, and under the present organization a complete understanding of duties will be promoted. The addition of a Permanent Treasurer will also provide a means of furthering a better organized business department.

A STEP AHEAD

For many years it has been desirable to have the Undergraduate express his ideas in an intelligible manner. It has also been true that with its mushroom growth, Purdue has men in its Academic courses who have had very exceptional training and experiences. There will be found in this issue several very interesting articles written by undergraduates. This is an experiment that will no doubt prove a success.

Department Notes

SCHOOL OF CIVIL ENGINEERING

THE LABORATORY FOR TESTING MATERIALS

During the past year an Impact Machine and a large torsion testing machine have been installed, which provides for tests in compression and flexure. The Impact machine formerly installed, provides for tests in tension so that the University is now prepared for various kinds of impact tests of materials. The research in progress in the laboratory includes investigation of methods of improving the manufacture of concrete sewer pipes; the investigation of the properties of alloy steels under quick applied and alternating stresses; the investigation of the best division by screening of the output of Indiana gravel beds.

HYDRAULIC LABORATORY

The new installations of machinery in the Hydraulic Laboratory are now complete. The new construction includes a concrete channel, 8 feet wide with large weirs, and a 50,000 pound scale for weighing the flow. Underneath this channel is a large underground reservoir. There is a 12 inch water turbine and a 20 inch centrifugal pump connected up with a steel pressure tank from which also provision is made for a study of discharge through orifices and nozzles under high pressure. This laboratory now has a capacity of 8,000 gallons per minute and the available head of 500 feet. This finely equipped laboratory has been developed by changes in the former machine shop at a very small cost. The experimental work under way includes the flow of water through bent pipe and valves, of the flow of water in concrete channels and also the resistance caused by different forms of bridge piers.

SPECIAL RESEARCH

Professor Albert Smith has completed a very patient and difficult study of the stresses in steel frames of high buildings caused by wind forces.

Professor Albright has continued his measurements of the deformation of railroad tracks under different operating conditions, for the purpose of throwing light on the proper design of ballast, ties and rails.

Professor Geo. E. Martin entered upon his duties as Assistant Professor of Highway Engineering and has spent a larger part of his time in highway extension throughout the State of Indiana. Purdue Road Schools are being held in various districts of the State at which practical problems peculiar to Indiana are discussed.

ENGINEERING CAMP

The engineering camp of the summer of 1914 was held on the State Forest Reserve near Henryville, about 20 miles south of Kentucky, and this summer will probably be held at Pentwater, Michigan. This camp has proved a great success, not only in equipping students as engineers, but has generated a general effectiveness that shows itself to a marked degree in the work of the Junior year.

INDIANA FLOOD COMMISSION

During the past year, the engineering office of the Indiana Flood Commission was installed at the School of Civil Engineering. Professor Hatt as Chief Engineer, was assisted by Professor Wiley, Professor Albright and Mr. Lommel. The report of the Chief Engineer was issued as a bulletin of the Indiana Bureau of Legislative Information.

SCHOOL OF MECHANICAL ENGINEERING

CHANGES IN THE INSTRUCTIONAL STAFF

During the past year several changes have been made in the personnel of the instructional corps of this department. Prof. T. T. Eyre has returned after a leave of absence of one year, in which time he was head of the Department of Mechanics, Hydraulics and Testing Materials Laboratory of Case School of Applied Science. The department has lost in the last year, Prof. L. E. Endsley, who at the present time is Professor of Railroad Engineering at the University of Pittsburg. Mr. A. O. Gates has resigned to take a position as Assistant Sales Manager for the Dodge Manufacturing Company of Mishawaka, Indiana.

The department has had the use of a large amount of apparatus in connection with the Steam and Gas Engineering and the Heating and Ventilating Laboratory.

RESEARCH

Thirteen lines of research were completed far enough to be worthy of publication and a number of problems are still under investigation during the last year. Quite a number af articles and reports were published also during the last year.

SCHOOL OF ELECTRICAL ENGINEERING

The personnel of the instructional corps of the School of Electrical Engineering has not been radically changed this year, Professors Harding, Topping, Rowell, Ewing and Still being its representatives on the faculty and the instructors remaining as before. Messrs. L. L. Bouton of the Kansas Agricultural College, later with the General Electric Co., at Schenectady, and H. E. Phelps of Worcester Polytechnic Institute were added to the staff as assistants.

The west room on the first floor of the Electrical Building, which has been occupied as an office by the head of this school for many years is now being transformed into a reading and conference room for the Purdue Branch of the A. I. E. E. and the three south rooms on the first floor have been devoted to office purposes.

Research work in connection with the high tension laboratory and the test car has been continued during the year and a high voltage voltmeter operating upon an entirely new principle is being constructed in the former laboratory which, it is anticipated, will be of considerable scientific merit. Aside from the usual research and commercial tests which have been carried on there is at present in operation a life and contact resistance test of a large variety of types of signal relays used upon block signal track circuits. This work is being done for the National Signal Association and is attracting considerable attention.

SCHOOL OF CHEMICAL ENGINEERING

The school continues to grow at a healthy rate, the total enrollment this year being 160, compared with 139 last year, including a senior class of 20.

In spite of the unsatisfactory condition of the business world the graduates have all been employed in technical positions in so far as they so desired, and more could have been placed if available.

Some rearrangement of the work has been made, several subjects being transferred to more effective parts of the course.

The staff of the chemistry department has been enlarged by the appointment of Dr. H. E. Loomis, assistant professor in Bowdoin College, to take charge of physical chemistry, formerly administered by Professor Mahin, who now directs the work in quantitative analysis only.

It is expected that some of the seniors in chemical engineering will receive instruction in physical chemistry next year and hope that arrangements can soon be made for a year's work for all in this increasingly important branch of chemistry.

Research work has been conducted this year on the destructive action of chemical solutions on concrete, the efficiency of automobile fuels, and the properties of lubricating oils.

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1916

No. 12 MAY, 1916

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Engineering Review Authors for 1916

MR. GEORGE DeA. BABCOCK (*"The Exact Control of Manufacture"*) was born in Corvinne, Utah, in 1875 and received his preliminary education at the Fairfield Military Academy. In 1904 he graduated from Purdue, receiving the degree of B. S. E. E. Before entering Purdue he had some experience in teaching and after graduation he accepted the position of Professor of Mechanic Arts at Syracuse University. In 1907 he became production manager of the H. H. Franklin Mfg. Co., which position he holds at the present time. He is a member of the Taylor Society. He is the author of "Results of Applied Scientific Management," an address before the Metal Trades Association in 1914, and reprinted by the "Iron Age;" "Routing Schedule and Despatch," an address before the Efficiency Society and reprinted by "Iron Age;" "The Executive's Problem," an address before the Manufacturers' Association, reprinted by "Iron Age;" as well as many other articles printed in technical magazines, and addresses before technical societies on the general subject of manufacturing efficiency. Mr. Babcock is generally recognized as being one of the leading authorities in the country on the subject of the application of the principles of Scientific Management.

MR. A. H. BRYAN, A. C., M. S., (*"White Sugar—Cane or Beet?"*) was born in Indianapolis, Ind., in 1874. In 1892, he graduated with honors from the Shortridge High School of that city and was assistant instructor in Chemistry at that institution from 1892-1896 and Asst. City Chemist of Indianapolis from 1893-94. In 1896, he entered Purdue University, graduating two years later with a B. S. Ch. E. degree. From 1897-98, Mr. Bryan was assistant to Dr. W. E. Stone, then Professor of Chemistry at Purdue. From 1898-1901, he was Asst. Chemist of the Indiana Experiment Station; from Jan. to Sept., 1901, Chemist of the Indianapolis Rubber Co.; 1901-1907, Chemist for the American Beet Sugar Co. of Rocky Ford, Colo.; 1907-1909, Asst. Chemist and from 1909-1914, Chief of the Sugar Laboratory, Bureau of Chemistry, U. S. Dept. of Agriculture; and from 1914 to date, he has been Supervising Chemist of the Arbuckle Bros. of New York City. Mr. Bryan is a member of the Indiana Academy of Science, Washington Academy of Science, American Chemical Society, Association of Official Agricultural Chemists, Vereins Deutscher Zuckertechniker, and the National Geographic Society, and has contributed many articles to the technical press, among which are, "The Sugar Beet," "The Chemical Composition and Analysis of Imported Honeys," "The Use of Light Filter Cell in Polarizing Sugars," "Precipitation of Reducing Sugars with Basic Lead Acetate."

MR. F. F. CHANDLER (*"Is the Answer Yes or No?"*) was born in Indianapolis in 1876 and attended the schools there before entering Purdue. He was a teacher of Advanced Physics in the Indianapolis High School for two years before coming to Purdue. He received the degree of B. S. M. E. in 1899. After graduation he was an assistant at Purdue for a year and then became Sales Manager of the Chandler and Taylor Company of Indianapolis, where he is located at the present time in the capacity of sales manager. Mr. Chandler has delivered several lectures before various bodies on the subject of "Corporation Management," and is the author of a number of papers and addresses on Power Plant subjects. He is a member of the Indiana Engineering Society.

MR. C. C. CHAPPELLE (*"Coasting Recorders For Checking Electric Car Operation Efficiency"*) was born at Carthage, Ind., and graduated from Purdue in 1895 with the degree of B. S. M. E. From this date to 1898, he was Manager and Treasurer of the Merchants Electric Light Association of Lafayette, Ind., which he organized. From 1899-1910, he was Engineer and Sales Manager of the Denver, Colo., office and later the Western Sales Manager of the Westinghouse Machine Co., of East Pittsburg, Pa. From 1911-14, Mr. Chappelle was Vice-President and General Manager of the Federal Light and Traction Co. of N. Y. Since then he has been Consulting Engineer and Vice-Pres. of the Railway Improvement Co., of N. Y. Mr. Chappelle is a member of the Western Society of Engineers and of the N. Y. Railway Club, and has contributed to the Electric Railway Journal, "Fundamental Principles of Car Operating Efficiency."

MR. A. B. COHEN (*"Expansion and Construction Joints in Reinforced Concrete Viaducts"*) was born at Chicago, Ill., in 1882, and graduated from Purdue with the B. S. C. E. degree in 1905. In 1910 he was given the degree of C. E. by the same institution. Previous to his graduation, he had two summers' experience as rodman and instrument man for the City Engineer of East Chicago, Ill. From June-Dec., 1905, he was draftsman in the Maintenance of Way Dept. of the D. L. & W. R. R. and from Dec., 1905-Sept., 1906, he held the position of Chief Draftsman locating Cut-off Line of the same department. From Sept., 1906-Feb., 1907, he was a draftsman for the C. I. & S. R. R.; March, 1907, he re-entered the Engineering Dept. of the D. L. & W. R. R. as draftsman in the Concrete Dept., and from May, 1907, to date, he has been Engineer of Concrete Design for that railroad. Among Mr. Cohen's engineering designs are the Martin's Creek viaduct, the Tunkhannock Creek and many others, ranging in length to 2230 ft., and in cost to $1,400,000. He is a member of the American Society of Testing Materials and of the American Concrete Institute, as well as an associate member of the American Society of Civil Engineers.

MR. R. G. FLAUGHER (*"Principles of District Drainage Assessments"*) was born at Cayuga, Ind., in 1889 and entered Purdue in the School of Civil Engineering, from which he was graduated in 1912 with the degree of B. S. C. E. Since then he has served in highway work; drainage and mining engineering; railroad surveying; as county surveyor of Vermillion county, Indiana; City Engineer of Clinton and Cayuga, Ind.; and as Valuation Engineer of the Toledo, St. Louis and Western Railway. At various times he has taken work in the Schools of Agriculture of both Purdue and Illinois.

PROF. M. J. GOLDEN, M. E., ("*The Operation of the Control Board*"), Professor of Practical Mechanics at Purdue University, graduated from this institution in 1894. He is a member of the A. S. M. E., the Society for the Promotion of Engineering Education, and the Indiana Academy of Science. Prof. Golden has written the Woodworking, Pattern Making and Foundry parts of the I. C. S. textbooks, "Wood Turning," "A Foundry Course for Schools," and many other articles and textbooks.

MR. G. E. GLOSSOP ("*Fatalities and Serious Shocks Caused by Electricity*") was born in 1889 at Ft. Dodge, Iowa. After gaining four years' experience in ordnance and seamanship in the U. S. Navy, he entered Purdue in 1910, graduating in 1915 with the degree of B. S. E. E. While at Purdue, he won a "P" in football in 1911, '12, '13, and was assistant football coach at Purdue, 1915. From 1915 to the present date, he has been Mathematics Instructor and Athletic Director of the High School at Rapid City, S. D.

MR. W. A. HANLEY ("*Modernizing a Boiler Plant*") was born at Greencastle, Ind., in 1886. He received his preliminary education at St. Joseph's College, Collegeville, Ind., and after four and one-half years' experience with the Republic Iron & Steel Co., of Muncie, Ind., and one year with the Broderick Co., of the same city, he entered Purdue in 1907, graduating in 1911 with the degree of B. S. M. E. From that time to the present date, he has been Chief Engineer of the plants of the Eli Lilly & Co., of Indianapolis, Ind. He is an associate member of the A. S. M. E.

MR. A. H. KROM ("*Plans of the American Association of Engineers*") was born in 1888 at Lockspring, Ind. He graduated from Purdue in 1910, receiving a B. S. E. E. degree. Previous to entering Purdue, he had gained experiences in carpenter and machine shops and in salesmanship. After leaving Purdue, he was electrical operator for the Commonwealth Edison Co. from 1910-11 and Commercial Engineer from 1911-12. From 1912-13, Mr. Krom was Chemical Engineer and Manager of the Chicago office of the Haskins Glass Co. From 1913-14, he was Power Engineer of the Central Illinois Public Service Co.; from 1914-15, City Electrical Engineer of Chicago; and from 1915 to date, Engineer-in-charge of the Chicago office of the State Public Utilities Commission of Ill. Mr. Krom is an associate member of the A. A. E. and of the A. I. E. E. Among his contributions to the technical press are: "Armature Reaction," "Semi-Indirect Illumination," and "Compensation for the Man Between."

MR. W. T. MILLER (*"Condensation Meters"*) was born at Neponset, Ill., in 1884, and is a candidate for the B. S. M. E. from Purdue this year. Before entering this University, he had gained practical experience in handle making; had operated a steam shovel on the Rock Island Lines for 14 months; was in the Indian service for two years; was principal of an Oklahoma Indian school and supervisor of the district Agricultural schools of the Oklahoma State Board of Agriculture for five years. Mr. Miller has had charge of power plants at various times and has obtained considerable practical experience along this line.

MR. HARRY G. RASCHBACHER (*"Notes on Estimating the Growth of Cities"*) was born in Indianapolis in 1881. He graduated from Purdue in 1904 with the degree of B. S. C. E. Since then he has served as Irrigation Engineer for the U. S. Department of Agriculture; Civil Engineer and Irrigation expert in the west; consulting engineer; and Assistant Professor of Surveying. He is a Consulting Engineer at the present time. Mr. Raschbacher is a member of the Western Society of Engineers, and the Michigan Engineering Society. He has published a number of reports on Irrigation Practices for the U. S. Department of Agriculture, and several articles for the Engineering Record, as well as articles for college technical publications.

MR. J. D. RAUCH (*"The Evolution of Excavating Machinery"*) was born at Logansport, Ind., in 1874. He entered Purdue in 1891 and left at the end of his Sophomore year. From 1893-1895, he was employed in a County Surveyor's office; from 1896-1900, he was a draftsman for the Pennsylvanda R. R. Co.; from 1900-1902, Assist. Master Mechanic of the L. E. & W. R. R. Co.; from 1902-1903, Mechanical Engineer of the Pennsylvania R. R. Co.; 1903-1906, Chief Engineer of the Wm. Dowling Co.; and from 1906 to date, he has been Secretary and Treasurer of the American Steel Dredge Works, Fort Wayne, Ind., which he organized in 1906 and which was incorporated in 1909.

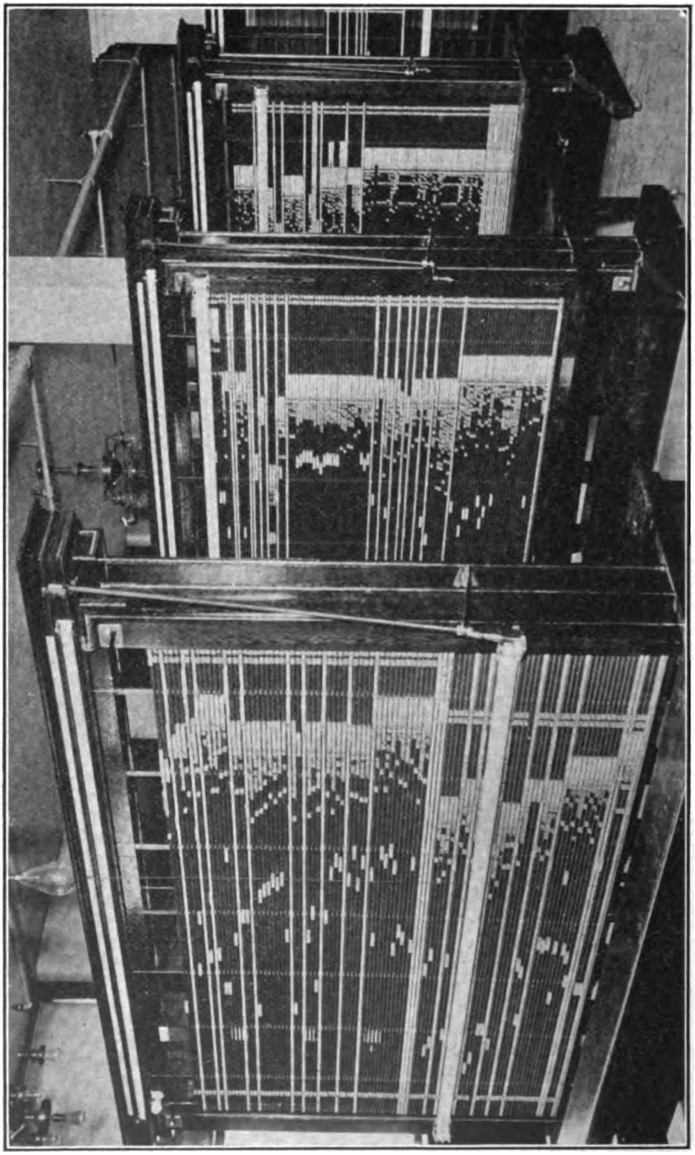
MR. W. E. STANLEY (*"Loss of Head in Pipes, Bends, Valves and Other Fittings"*) was born at Burton, Kans., in 1891. He graduated from the Kansas State Agricultural College in 1912, receiving a B. S. C. E. degree. From Aug.-Dec., 1912, he was bridge inspector for the state of Kansas; from 1912-13, he was employed as chainman on U. S. land surveys; and from 1914 to date, he has been an assistant in the School of Civil Engineering, taking a graduate course in Hydraulic Engineering. He is a candidate for the degree of C. E. and is a member of The Society for Promotion of Engineering Education.

MR. L. E. STIBBE (*"Some Phases of Railroad Traffic Study"*) was born in Valparaiso, Ind., in 1892, and graduated from the high school at Kants, Ind. He graduated from Purdue in 1915 with the degree of B. S. E. E. Since then he has been employed in the Testing Department of the General Electric Company. He is a member of the Schenectady branch of the American Institute of Electrical Engineers.

MR. J. C. TURPIN (*''Some Personal Impressions of Aviation''*) was born in 1886, at Dayton, O. He graduated from Purdue in 1908 with the degree of B. S. M. E. Previous to entering Purdue, he gained much experience in working with automobiles and motorcycles. From 1909-1912, he was an aviator and salesman for The Wright Co. of Dayton, O., being one of the seven members of the Wright Exhibition team. Retiring from the field of aviation in 1912, he entered the sales department of the Packard Motor Car Co., of N. Y. From 1914 to date, he has been a member of the firm of the American Cotton Co., of Boston, Mass.

PROF. L. W. WALLACE (*"Shop Control"*), Professor of Railway Engineering and of Industrial Management at Purdue University, is a graduate of the Agricultural and Mechanical College of Texas in the class of 1903. He received his M. E. degree from Purdue in 1912. Prof. Wallace is a member of the A. S. M. E.; the International Ry. Fuel Association; the Western Railway Club; the Western Efficiency Society; the American Academy of Political and Social Science, and is an Associate Member of the American Railway Master Car Builders Association. He is President of the Indiana Engineering Society. Prof. Wallace has been a frequent contributor to the technical press of many articles on railway subjects as well as of those along industrial lines.

Main Entrance to Purdue University.
Mechanical Building in background.



The Control Boards in the H. H. Franklin Mfg. Company's Plant.

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EXACT CONTROL OF MANUFACTURE*

By GEORGE DE A. BABCOCK, '04 †

Synopsis: A discussion of the application of scientific management to a manufacturing business, taking up the principle elements which enter into the intensive control of manufacturing work and explaining in detail how each may be scheduled and despatched with precision. This article is supplemented by illustrations and an explanation of the control boards used in the H. H. Franklin Mfg. Co's. plant, Syracuse, N. Y. to obtain the exact control described by Mr. Babcock in this article.

Recently the writer addressed the Manufacturers' Association of Auburn, N. Y., on the subject, "The Executive's Problem." The theme of this address involved different types of executive action as applied to the conduct of a business. Three fundamental types of executive action were presented, the third one of which is commonly known as Scientific Management. It is a type of management promulgated and practiced by our late Dr. Frederick W. Taylor, in which the executive assumed a more detailed control of work than practiced under other forms; in which facts supplant opinion and exact instructions supplant general orders. Tasks are set for each element of the work and a perpetual check of accomplishment to these tasks is maintained.

I shall go into a somewhat extended discussion of the application of this type of management to a manufacturing business and from examples gathered over a period of four years of its practice in a most intensive form acquaint you perhaps better than in any other way with what repayment may be expected to offset the strenuous effort required for its introduction and continued application.

The writer has been highly favored in the past with an opportunity to present the results of these experiences before Societies, Associations, and Universities, most of which have been recounted in the "Iron Age" magazine. It has been his aim to prepare a discussion on different phases of this work upon each of these occasions. This paper includes but little of the detail of that which has been previously written.

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* Address given before the University Industrial Society, Bridgeport, Conn., December 3, 1915.

† Production Manager, The H. H. Franklin Mfg. Co., Syracuse, N. Y.

Preliminary to any active work in the factory, the management and more important supervisors must at least agree to be in accord with the new efforts and to give their honest support to such efforts. Those responsible for the work of reorganizing will be reflected by successful or chaotic results. If you fail or go into it with a half-hearted or unscientific approach you will be worse off than before you started. If you support and carry it to a successful conclusion, as it will invariably be if carried through, you will marvel at the comfort and lack of discord which permeates your whole works.

The principal elements which enter into a manufacturing effort, arranged in the order in which they will be discussed, are:

- (a) Stock on hand available for production.
    1. Productive materials.
    2. Patterns and dies.
    3. Supplies
- (b) Material and work in process of production.
    1. Buildings.
    2. Machines and equipment.
    3. Materials.
    4. Tools.
    5. Men.
- (c) Money.
    1. In production.
    2. In supplies and indirect expense.

THE CONTROL OF STOCK MATERIALS

Develop a set of controlling records for the stock, which are designed to be absolutely dependable without undue supervision.

Perfect the inspection of incoming materials to the end that inspection precedes receipt into the stock room or records and that no rejections shall occur after such record. To secure this, specifications must be exact and the education of the inspectors with respect to the specification complete.

(*Example*: At the end of our year 1911, the variation in stock room physical inventory with the records was 2½% of the value of charges handled during the year. At the end of the year 1913, the variation was .03%. At the end of the year 1914, the variation was .01% of all such charges.)

Upon this foundation material schedules, in and out of stock, can be attained with unbelievable exactness.

To insure materials being in stock on required dates, the Purchasing Agent must provide for the schedules standard purchasing times for each material class, as forgings, grey, malleable, aluminum, or bronze castings, cold rolled bars, nickel steel bars, etc. These standard times are the minimum number of days in which the representative can regularly bargain, buy and deliver to stock each class or special item. From time to time such list will be modified as changes of conditions require.

(*Example*: The standard list now in service contains seventy-two classes and items. It is dated May 11, 1915, at which time it was last revised. To this date, with all the assumed difficulty of obtaining materials, only six changes have been made in time allowances in this list. At this date 4,000 lots are on order with the Purchasing Agent. About 100 lots are issued to the shop each day. 90 lots are now waiting to be issued as overdue. This represents about one day's delay.)

The purchasing representative must be specific in requiring that deliveries of materials neither precede the specified date or delay beyond such date. Some variation must of course be provided between the date of delivery to stock and date to send into process. This should be a standard time.

(*Example*: The present standard of stock time is ten days; i. e., if no more stock were received but issues continued per schedule, the stock would be entirely depleted in ten days, assuming that receipt and issues occur exactly to schedule. Practically, we have attained in late months an actual stock reduction to eleven and one-quarter days' supply without detrimental effect upon productive output or direct productive costs. Previous to new methods and present control plan, the stock investment represented a fifty days' supply. This automobile stock is evidently composed of a great variety of classes as well as characteristic parts. Some material is stocked for a complete schedule of six months or more up to three years for lumber. Such material is usually small in bulk, large in numbers and of relatively small value. Other material of appreciable bulk and value may be stocked to the short period of one week.)

From the above we conclude that control of stock has been obtained. Six principal items require control.

1. Requisition of material.
2. Placing of purchase order.
3. Securing of acknowledgments.
4. Receipt of invoice showing shipment of material.

5. Receipt of material into stock.
6. Issue of material to process.

PATTERN CONTROL

For castings, a pattern must accompany the requisition This, therefore, must be controlled. The principal items entering are:

1. Pattern order placed.
2. Work started.

3, 4, 5, etc. Percentage completed.

6. Delivery to foundry for test casting.
7. Casting received.
8. Issued to shops.

9, 10, etc. Percentage of casting tested.

11. Test completed, and if satisfactory, release the pattern to Purchasing Agent to ship to founder for production, or to local founder, from the local pattern control. If not satisfactory, recall the pattern and repeat.

CONTROL OF DIES FOR FORGINGS

This plan is similar to that for patterns. The control items are: (1) Order dies. (2) Secure and inspect lead proofs. (3) Release dies for test forgings. (4) Test out forgings to jigs or for hardness or chemical analysis. Release of dies for production.

SUPPLY CONTROL

Supplies for the shops are controlled under a budget plan. In recent years there has been accumulated a vast amount of information relative to the consumption of perishable supplies at the different classes of machines. This includes grinding wheels, polishing wheels, oils, waste, perishable tools, etc. From this accumulated information budgets are prepared for each department for each month and dates of deliveries of supply materials are controlled to agree with these budgets. While there may now be some variation, the increase of accumulated information will soon make it practically exact.

Supplies are despatched from the stock rooms sometimes with tools for the job, and at others to the workmen directly, as they come for jobs.

CONTROL OF MATERIAL WORK IN PROCESS OF PRODUCTION

This class of factory effort calls for the greatest activity on the part of the organization due to the many complex groups which enter. These principal groups are: (1) Buildings. (2) Machines and equipment. (3) Material. (4) Tools. (5) Men.

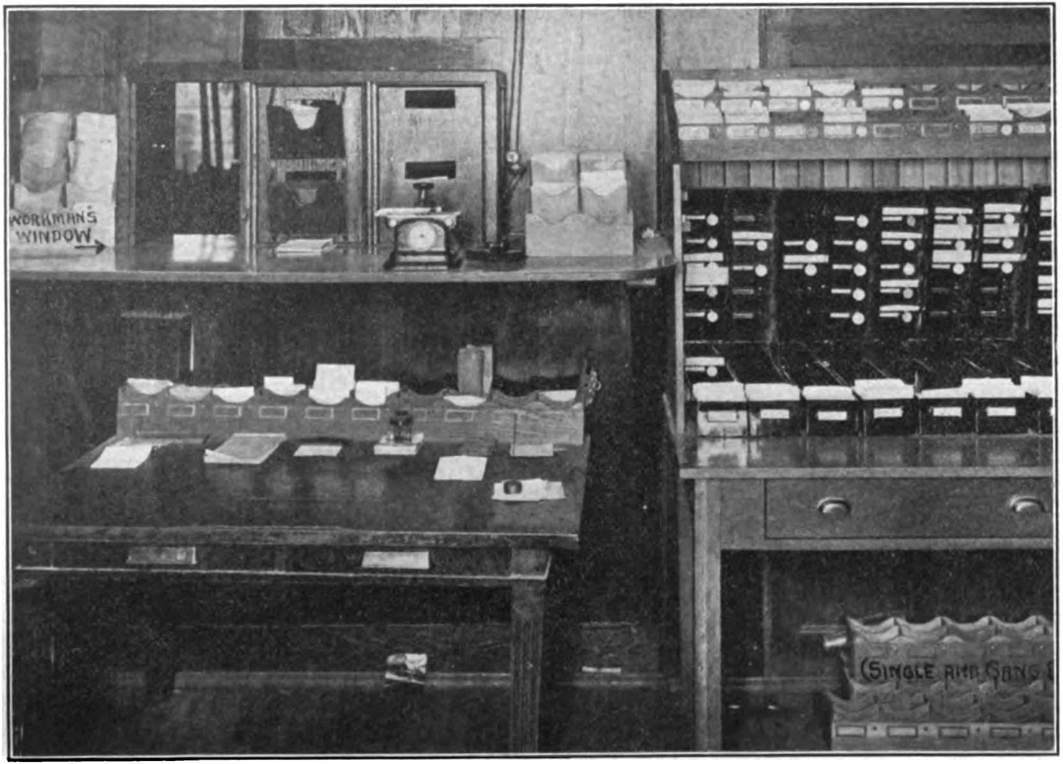
No group or subdivision of a group can remain in partial or without control and the final results be controlled. If the product is complex the least unbalance in the schedules of the groups will cause immediate congestion with a consequent temporary suspension of work in some divisions followed by a corresponding period of excessive activity. There will first be unemployment and later overemployment; idle plant and machines, with later a congested plant and machines. Delayed or limited material may be the cause of a greater congestion than material in advance of schedule. Either condition causes not only extreme dissatisfaction to all persons affected but it means large permanent investments in buildings and other fixed equipment for temporary use as well as unsalable material and labor.

A uniform burden on the works at the minimum investment is so desirable that all possible effort in this respect will be amply repaid if the classified plan of control is obtained and perpetually applied.

BUILDING CONTROL

The control of buildings for an ascending schedule is not difficult. Plans are laid as for materials and machines. All of the activities which are represented are analyzed and classified. Each class is further divided into its elements and the date for each element to start, proceed and finish is set. The setting of each date is made with reference to the date for the finish of the completed structure. The time for measurements, i. e., the time required to produce each element, is predetermined from exact knowledge and estimates. Promises of architects and contractors are not altogether satisfactory, since rarely do they have the opportunity to plan and supervise as intensely as is customary under the highly developed factory method.

The control of buildings for a descending schedule unless they can be sold for cost loss depreciation is never satisfactory. Some relief can be obtained by maintaining peak loads in outside rentals, never carrying a building equipment for probable peaks. The possibility of securing such outside



A substation from which one of the machine shops is controlled. The boxes shown in this photograph contain the time cards which have been written for the workmen and these time cards represent both the work they are actually engaged on and the work which will come to them next.

rental is a factor to be considered, for without it, it is either build or pass the business and the latter is not always the least objectionable.

(*Example*: Storage spaces for materials are constructed identically as for manufacture. As these spaces become occupied with manufacture, materials are crowded out into rentals until the permanency of this rental is evident, then new buildings are provided to house the permanent part of the overflow.)

CONTROL OF MACHINES AND EQUIPMENT

The fundamental of control of machines is the burden. "What machines" and "how many" for a given rate of output of a known product is a perplexing question. Expert mechanics of highly inventive ability in the planning room will specify the first part of this question, i. e., "What machines." The regulation of "how many" to produce a varying schedule of output can be secured through exact record of the time in which the machine can produce each operation on each piece which is routed over it. If the product is such a one or similar to that now considered, a burden record can be compiled to show each machine by number or symbol with all operation time routed to it for one unit of the finished product. The sum of such times for each machine multiplied by the number of product units to be made each day will give daily task. This daily task divided by the number of machines will give the daily burden. This burden divided by the number of time units in the standard day will show the number of machines required. Two essentials for the success of this plan are proper time allowance for machine breakdowns or idleness and exact knowledge of unit times for each operation. There is no way of securing this latter except by elemental time study. Since the machine operator's activity is a factor in the time taken by the machine, the operator must also accomplish his effort in the set time. This is prescribed in the instruction card with which the operator is provided. Regardless of the payment of a premium or bonus to the man for special attainments, it is absolutely essential for the welfare of his fellows, as well as the stability of the business, that the machine unit times be obtained and applied. Any delay on a part causes a delay of the assembly into which it goes with a consequent suspension of work of the assemblers. There will also come overdue shipments to the consumers.

The operations on parts which go over each machine having been recorded, from the schedule of the particular operation of that part which must be first worked upon, a date can be obtained for the delivery of the machine to its place on the work floor.

All machines planned for the same kind and quality of work are speeded, powered and made exactly alike in all mechanical respects. They are then classes in groups so that work routed to one can be placed with any of the others with certainty of predetermined standard performance. The group carries the group burden and in all respects acts as one machine. Each machine in the group is regularly inspected and repaired. Lubrication for cutting edges is controlled by a central equipment circulating to all places of use in the shops.

Example: Some of the groups and number of machines in each group as now arranged are:

Power mills, class 10, group of 4.
Power mills, class 24, group of 2.
Power mills, class 42, group of 3.
Hole grinders, class 11, group of 4.
Turret lathes, class 9, group of 8.
Polishing grinders, class 3, group of 12.
Drill presses, class 1, group of 6.
Gang drills, class 10, group of 6.

There is a considerable number of groups with from four to six machines in the group. The most difficult group is that of the turret lathes, class 9. Slight variation in the alignment of turret or spindle will eliminate the machine from the group.

With a larger productive output the number of machines in each group would grow practically proportional to the output.

CONTROL OF MATERIALS

No plans for control of materials over the varied paths in the works can be successful unless controls previously mentioned have been established and are perpetually maintained. Even with this satisfactory maintenance under the usual plans the detail in this effort is enormous. For exact control—and this is so much more satisfactory than that which is approximate—each activity on each part and assembly must be specified. One chief essential, but one seldom practiced, is the determination and standardization of lot sizes for each part. These lots will be moved from station to station on the routes as units, each lot to remain at each station until the work specified to be done at the station is completed on each piece in the lot. Without exceptional orders, once the work at a station has been started on a lot of one part, until it is finished no other lot of another part can be started. This precludes the use of stock chasers or other local shop authority since they are not in a position to judge the relative importance of delayed parts as against other work waiting at the machine when the delayed part reaches it.

Under a standard lot size plan the variations in quantity of output are obtained by corresponding variations in the frequency of despatching individual lots.

(*Example*: Assume a standard lot of finished product at Final Assembly to be 50 units, and the schedule to require 10 units per work day. Then lots of parts for final assembly will be despatched from finished stock each 5 work days. If a product part, one of which is used in each unit of the finished product, is moved in lots of 500 pieces, this quantity will satisfy the assembly for 50 work days and will be despatched from raw materials stock at that frequency. The same frequency will obtain at each station on the route. If each assembly lot is 25 days in process, then 5 lots will be in process at all times. If the lot is in process 15 days, then 3 lots will be in process at all times.)

Since the same kind of machine work will occur on many different parts, the order of approach of the parts to the machine must be controlled. The parts must be moved to the machines and be recorded at the machine before the work order is given to the operator. If machines are grouped the material must be delivered to the location of the group and this recorded as received. The first free operator in the group must then be given the part next due. This action is readily secured by dating each operation job card at the Control Board, which insures accurate relative order of work. The jobs for a given group of machines are arranged in a machine job card box in the order of these datings. Despatch boys local to the shops are held strictly accountable for the giving out of jobs to the operators in the order of dates. Any job not issued by a given hour, on the day specified is marked with a "Lot Urgent" card. This card is signed by a superior in the Planning Department, and upon this signature becomes a standing order to the superintendent and foreman to provide overtime or night work for the job. If any one part becomes overdue with aggravating frequency, or if a machine or group of machines is constantly marked with urgent cards, the Routing Division is called into consultation to advise a solution.

At the present time there are 12,000 jobs standing in the machine racks. There are an average of 600 jobs started per day. There are 450 urgent tags standing; i. e., one day's extra activity of the working force would bring all work in the shop up to schedule.

The variations in hour's work on overtime or night shift is slight. We conclude from this and from the fact that final product follows its schedule exactly, that average errors in operation are constant.

We also conclude that if no urgent tags stood against work, that the investment in work in process account would be excessive, i. e., we would be ahead of schedule on produced parts, which product would remain in an unassembled state lacking finished purchased parts for its completion.

Scheduling of standard lots, coupled with sure methods of despatching over well planned routes should obtain most beneficial results from the reduction of investment charge as well as the delivery of salable product.

These are two of the most important accomplishments in factory conduct. Known time elements are fundamental for this conduct. When known they must be obtained regularly in practice.

(*Example*: Previous to the control of our factory work by the above plan, the work in process investment account represented three and one-half cars for each car produced per month. Now it is one and one-tenth cars for each car produced per month; i. e., we turn our money over three times as fast as before.)

CONTROL OF TOOLS

Coincident with the routing of operations to machines is the specification of tools. These include jigs, templates, gauges, drills, taps, dies, wrenches, and the forms and sizes of all cutting edges. The date of tools due in tool rooms is specified and the minimum quantity to carry entered on the tool ledgers. The stock is maintained thereafter by the tool ledger requisition.

As each job comes up to a machine the tools are ordered out to agree with the tool list for the operation. These are delivered to the point of use, a signed receipt therefor by the floor executive, delivered to the despatch clerk releases the job if the receipt for material has been filed.

After tools are used they are returned to the tool stock for inspection, shaping of cutting edges and such repairs as are deemed necessary.

CONTROL OF MEN

Where large quantities of the same part are made or where the limited performance of a special machine is continuous, men are naturally employed steadily on limited work. This limited work is not a function of a particular kind of plan, but rather an economic specialization as is true in all branches of industrial activity from the engineer on a limited train to the farmer at his plow. The miles to go or the acres in the field limit the time of change of application of effort.

A complete knowledge of what is to be done and this taught to the workmen by written instruction allows quite unskilled men to become useful productive units. So many men and their work are misfits and employing men for what they can learn to do and not for what they know makes rather easy the task of the employment agent. Employment centered in a representative of the chief factory executive, and discharge possible only upon the written approval of this executive secures steady permanent workmen. Wages sufficient to interest them in outside investments, work hours which allow them time to supervise and enjoy such investment, permanency of employment assuring the continuity of this enjoyment aid materially to stabilize the force and assure a steady high grade output with much happiness in the working hours.

(*Example*: Of the force now employed, 20% are over 50 years of age; 5% over 60. The average age is 37. The average period of last employment for the whole force is four years; for one-half the force selected, six years. It is evident from this that the labor turnover is very slight.)

CONTROL OF MONEY

The index of successful industrial operation which makes comparable various kinds of work and various kinds of control of the same is, "money." I have indicated in this connection the effect of this work on investment charges. I wish to mention briefly the effects upon other prominent factors. The sale price of an improved product has been decreased 30%, caused by corresponding decrease in the costs. The average monthly earning of labor has increased 28% and is still rising. Supervising, or indirect costs, have decreased in the same proportion as direct labor costs.

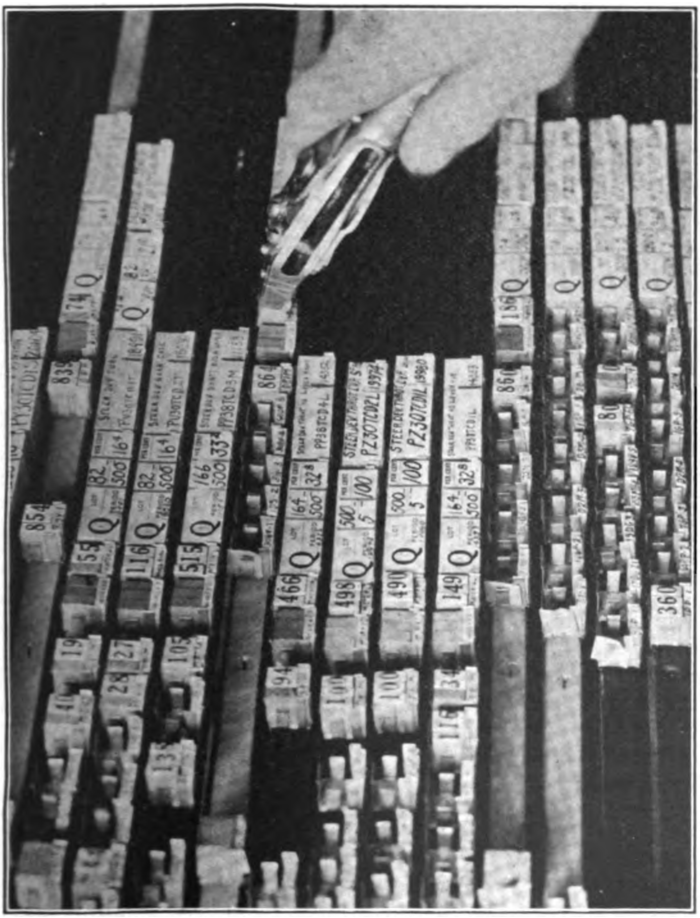
The control of money spent for indirect purposes is obtained through a supervisor and estimator, who, working from accumulated data, contracts, bids, etc., is able to specify very closely the cost of a given job. After proper approvals and the work is finished, the frequent checks against the work in process and the final result are referred again to the estimate and the experience so gained is applied to the next work of a similar kind.

CONCLUSION: It has not been the writer's intent to tell you all that can be told about the subject of intensive control of manufacturing work, but rather to indicate the elements which enter into such intensive control.

We have had many visitors to our works from nearby cities and there may be some among the readers of the Purdue Engineering Review, some whom it has been our pleasure to entertain. They can bear me out in the statement that many days could be spent over the details which enter this problem and then perhaps not clearly analyze the solution which we have made as compared to their own problem.

Time, as has been mentioned, is such an essential in the carrying on of a complex business, that regardless of all of the activities of persons hostile to time study, they will never stem the tide of the flood of effort and thought toward a solution of this problem in which fact will supplant opinion, and true knowledge will eliminate the fear which now leads to any organized opposition. Premium or bonus methods of payment are not essential in any plan of Scientific Management if anything can be substituted therefor which will cause a task set by known facts to be carried out regularly.

I feel that the industrial world is greatly in debt to Dr. Taylor and his associates who have assisted in the promulgation of these principles, and although the way in which they may have been presented may not appeal to some persons, the experiences of industries which have tried conscientiously to carry out the principles without change will sustain the truth of the statements which have been made with respect to them.



Detail of Control Board.

THE OPERATION OF THE CONTROL BOARD

By M. J. Golden*

Synopsis: Supplementing the explanation of the control boards illustrated in the preceding article.

George D. Babcock, of the class of 1904, now Superintendent of Production of the H. H. Franklin Mfg. Company, of Syracuse, N. Y., has developed a method of inspection of his Production Department that is unique and exceedingly interesting; a scheme by which he tells just the condition of any given order at a glance. A good idea of the method can be obtained by a description of its actual operation on an order at the time of the writer's inspection of the system.

An order for 400 machines had just come in from Detroit. This order was divided into groups with 17 machines in each group, as 17 machines could be carried on simultaneously with the apparatus that was available in the shops.

A board of about 4 feet x 12 feet was prepared in such way that small blocks of wood one-half inch square could be attached to the face of the board. In examining the details of construction, the particular piece that took the greatest amount of time was placed on the board by its number and letter at one extremity of the board and then each piece that went to make up the total machine, placed on the board at the time when this piece must be started to have it fit in with the construction of that particular group of machines.

It was found for illustration that the greatest amount of time was taken by one of the small pieces that went to make up the steering post. Then this piece was placed at one extremity of the board and the other pieces that went to make up the machine were placed each in its proper place on the board, the total board representing the time from the starting of the machine to the time when it is delivered on the floor.

Now the board is divided into time units. Fifteen units are taken for the unit of division. An inspection of the board will show when each piece of the machine ought to be completed to within this limit of fifteen minutes. If at the end of, say, four days, the pieces that ought to be completed at that time are not completed and properly delivered, an inspection of the board will show that fact, as on the completion of any given piece, its letter and number are taken from the board at once.

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Now in the orderly procession of this group through the shop, if any one piece falls behind, an inspection of the board will show that fact at once because the block containing its distinctive mark is still on the board, whereas if the work is going along properly, the number back of the given date ought to be empty. If a piece does fall behind, provision is made for it by putting it in as night work until it is brought up to its proper time.

Now, of course, the particular feature of this scheme is that a glance at the board will tell the story at once as to whether or not any particular order is coming along as it should.

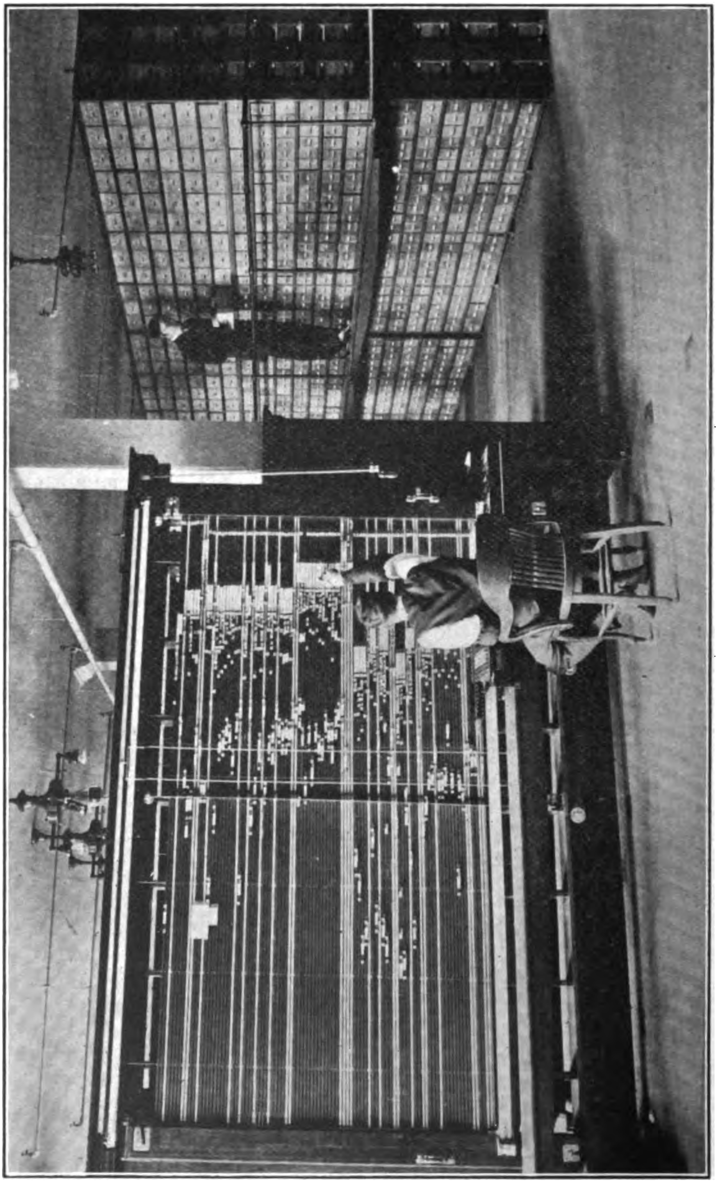
At a time when a boy who has not any great degree of skill starts to arrange the details on this board, there is started in the order department a full set of order cards and other necessary instruction, and reports that go with this particular group in its progress through the shop so that before the work is started in the shop there is prepared an inspection board and a complete set of orders and instruction cards, and every detail of the work is anticipated.

As against one thousand workmen employed in the shop in the production department, there is a clerical force slightly in excess of one hundred employed in filling out order blanks and other cards that go with the particular group in hand.

An idea of the success of this method may be had from these incidents: a group of machines that had been in process of construction during seven days was found to have three small items that had dropped behind, and an inspection of the number for that particular group showed this fact at once, so that the manager was able to provide for those three pieces as night work and have no interruption in the work later at the time of assembly.

As an incident of this method of handling work, a line of maximum production with the use of the apparatus that is available in the factory is established after considerable experiment, and the effort with each group is to approach this line.

Mr. Babcock assured me that except as he introduces new schemes in the shops, though production manager, he is, under this system, one of the least busy persons in the establishment, and an inspection of the scheme will develop at once why this is so.



(From *Iron Age*)

To be able to purchase material so that it is ready at the logical time for machining or assembling or both and still maintain the most economical investment of capital; to be able to issue such as is machined to the shop at the proper time and in most economical lot sizes; to finish the parts in the shortest time consistent with good workmanship, and finally to deliver all parts to the assembly floor and insure the completion of the finished car, is with the H. H. Franklin Mfg. Company taken care of to a great extent by the Taylor system of scientific management and the control boards shown are used.

A motor car consists of, say, two parts; the vehicle and the power plant or engine in the vehicle. Taking the engine and carrying the process of division further, it will be seen that the engine consists of several groups of parts which may be called divisions; these divisions in turn comprise groups which may be called sections; the sections are combinations of still smaller groups which may be called sub-sections, and so on down to the individual pieces. To illustrate, the carburetor constitutes something which may be assembled complete and attached to the otherwise complete engine. The carburetor division may consist of three or four sections which together with individual parts are assembled and constitute the complete carburetor.

The boards themselves are large frames containing a great number of horizontal strips. Across the top of each frame is an adjustable scale. Sliding up and down the frame parallel with the strips is a cross piece, or runner, also having adjustable scales in it.

Each horizontal strip has fastened to it several blocks. A small number of the strips are white in color, while the majority are black. Each black strip represents one part required in a finished car, while each white strip represents an assembly of the parts on the black strips immediately above it. Each of these assemblies forms one of the sub-divisions, sections or divisions, previously mentioned.

Taking any one black strip, it is noted that there are several blocks attached to it at different intervals along its length. These blocks represent each operation of a finished piece from the time of purchase to the time of its completion ready for use in assembling the car. The longer blocks at the left hand side represent the requisition for the purchase of the material for the part, the smaller blocks along the strip represent each step in the process of the part and the long strips at the right hand end represent the finished part. The spacing of these blocks and the length of the blocks themselves, is to a predetermined scale, and bears a fixed relation to the top scale and sliding scales previously mentioned. By means of numbers on the blocks themselves and the values of these numbers as compared to the numbers immediately above them on the top scale, the information is given as to whether a part is behind or ahead of schedule.

SHOP CONTROL

By L. W. WALLACE*

Synopsis: Showing how the principles of Scientific Management have been successfully applied by the H. H. Franklin Mfg. Co. to their automobile repair shop thereby refuting the statement that this modern idea in management cannot be applied to industries with many variables.

At the suggestion of the editors the following remarks are submitted concerning the shop control methods of the H. H. Franklin Mfg. Company. This discussion is based upon observations made at the Franklin plant in Syracuse, upon a number of conversations with Mr. Babcock, and by the information obtained through a very careful study of all that Mr. Babcock has written upon the subject of shop control.

Before entering upon a discussion of the subject the writer wishes to congratulate the Review Editors upon securing such a timely article from one so eminently qualified to write it. Mr. Babcock is generally recognized as one of the most prominent production managers who is practicing the new thought in management. The plant over which he has control employs more men than any other plant operating under Scientific Management. This adds emphasis to any statements that Mr. Babcock may make concerning modern methods of shop control. The achievements of Mr. Babcock have been noteworthy. His work has been constructive and unique. His control boards are marvels of conception and of execution. They can be fully appreciated only through a careful study and observation of them. Professor Golden has indicated some of their significant points. This discussion is not concerned with the control boards, however, but more particularly with the methods used in the Automobile Repair Shops of the Franklin Company.

Many have made the statement that Scientific Management may be all right for an industry of uniform product, quality and quantity, but that it will not apply in an industry when there are many variables. This statement has been disproven by actual practice in the plant of the H. H. Franklin Mfg. Co., for in that plant three separate and distinct lines of activities are conducted:

One: Motor car manufacture, of fairly uniform standards and requirements as to design, material and quantity.

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In the second case the manufacture of supply parts, for repairs, which parts are subjected to fluctuating demands; the demand varying both in quantity and pattern.

Thirdly, an automobile repair shop, where the demand is much more varied than in either of the other two lines of activity. It is questionable whether there could be an industry more variable in its several aspects than in the making of repairs to automobiles. If in the presence of so many variables such standards and methods can be adopted as to facilitate deliveries according to promise and at the same time reduce the cost, then indeed it may be said that the principles of Scientific Management are applicable to almost any industry.

To apply the principles of Scientific Management to an automobile repair shop certain things must be done; certain facts must be established. One of the first things to be done is to find out what the shop can do, what the facilities are and what the capabilities of the workmen are.

The second step is to find out what is to be done, and to determine the relationship between the several operations or processes.

The third step is to classify the jobs, the workmen and to perfect the organization and methods.

To determine what the facilities are is not a difficult task, inasmuch as an automobile repair shop does not require a large assortment of physical equipment. Neither is it essential or feasible to establish a complete or satisfactory machine burden in a repair shop of this character. Hence the question of physical equipment does not require a great deal of attention. But in such a shop the human equipment becomes of prime importance. Hence to know what that element of the shop facilities is capable of doing is an important step. In the Franklin shop this was arrived at by securing a written statement, from each employee in the repair shop, of what he could do. By this means the qualifications of each man became known. The men were then classified into groups as A, B. and C. This grouping was according to their ability. If it was found that a man overestimated or over-stated his qualifications he was penalized by being reduced two grades. If on the other hand it was found that he could do work in an upper grade, and that 50% of his time was spent on such work, he was then promoted to the higher grade.

According to the classification used each man was capable of doing all the work in his grade and also all the work in the grades below him. He was paid the rate of his highest grade, however. An effort is made to keep a man busy in his class, for that is the work for which he is best fitted. Also the higher the grade the better the class of work assigned. There is a constant incentive, therefore, for the men to want to be graded higher, because of the higher pay, more agreeable work and additional prestige. On the other hand, there is a motive for the employer to raise the grade of the workmen, because it makes a more flexible labor condition and more contented and happy workmen. Through this classification of labor the men are required to work on jobs for which they are best fitted; they are encouraged to push forward and are rewarded for accomplishment.

To find out what was to be done was accomplished by conferences. In these conferences the foremen, the works manager, and the superintendent gave their opinions. At first the conclusions and suggestions were very divergent, but as time passed a standard was arrived at by which each operation was classified and a standard time set, the standard time being established, largely, upon record of past performance. Having the men and the jobs classified and the time required for each operation it then become an easy matter to work out certain standard methods of procedure.

The work was classified into nine general classes, as follows:

A. Foremanship and inspection.
D. Road jobs.
G. Tune up and road tests.
K. Overhauling.
M. Light repairs.
P. Electrical work.
S. Body and accessories
V. Stripping.
X. Washing.

The arrangement of the classes of work was in the order of the ability and training of the workmen. A workman who could do Class A work was also capable of doing all the work required in the classes below A and likewise for each class of workmen. This being standardized, a despatch boy could give out work to men as they came to the window, knowing to what class each man belonged.

For each elemental operation of each class of work, detailed instructions were prepared as to how to proceed, as to tools required and as to materials and parts involved. The part numbers are shown on the instruction card, so the workman loses no time in instructing the material boy as to what is required.

In the preparation of the instruction cards the men, that is, the workmen, are encouraged to give suggestions. In fact many of the instruction cards have been prepared by the workmen at their homes at night and at off hours. For such work the company pays them liberally. Complete and detailed records have been kept from the beginning of the new order of things. Through the study and analysis of this information improvements are being made constantly.

With the organization perfected as outlined, a customer drives in. The superintendent, with an inspector and the owner makes an inspection of the car and agree upon what is to be done. The superintendent makes out a route sheet which shows the customer's name and order number, estimated date and hour of delivery and a statement, in paragraphs with symbols, of each element of the job. According to the standard classification, this route sheet becomes an agreement as to what is to be done and it is also a work order for the job. The owner is given a copy or one is mailed to him promptly. No work is done on the car that is not specified on the route sheet, until the owner's consent is obtained.

As the superintendent made out the route sheet he noted on the margin the required time for each elemental operation and the allowance time between each operation. With the date of delivery set, the time to begin work on each elemental operation could be set, even to the hour, in order to have the car ready for delivery at the time specified.

The route sheet was then sent to the planning room, where the Route File Clerk immediately translated the order and wrote a job card for each operation and symbolized it according to the standard classification. The job card consisted of three copies; the face copy being a small coupon; the second copy an inspector's and move ticket; and the third a workman's job card.

The job cards were then put in boxes in the despatch racks, especially arranged as follows:

A special box was prepared for each class of work. This box had two compartments. In the front compartment were placed all job cards for the jobs ready to be done. In the back compartment were placed the job cards that were written but jobs that were not ready to be worked upon. In the cover of each box was a compartment for the name of each man enlisted in that class of work. The arrangement of the names of the men in these compartments was in the order of their ability.

After the job cards were written they were given to a despatch clerk who placed them in the correct compartments. As a man completed a job he would turn in his job card. The clerk, knowing to which class of work he was assigned, handed the workman the first job card in the box of his class. As the job cards were arranged strictly according to date, the job card of the job needing the most immediate attention would be given out. If there was no work to be done in the class to which the workman belonged he would then be given the first card in the next lower class. The despatch clerk would not have to seek authority for this as that is a standing rule and practice.

If on the other hand a job was urgent, that is, behind schedule or the owner was waiting, then an urgent tag would go on, which would mean that the man who was ringing in on one job would be assigned this urgent job, although it was in a class below his own, and notwithstanding any orders that might be ready in his own class. Indeed, an urgent tag always implies that immediate steps must be taken to start some one to work on that job. This may mean the causing of a man to ring in on an assigned job before completed and take up the urgent one. By this system the schedule is maintained and the cars are delivered according to date and hour promised.

An hourly inspection is made of the bulletin board. By this inspection any orders behind schedule are discovered and an urgent tag is attached. At four o'clock each day the jobs to be worked upon are inspected as to dates. If any of importance are behind schedule an urgent card is placed upon them. The bulletin board is marked to correspond and curves are plotted which show to the superintendent the condition of orders. By the indications of these curves he is enabled to better schedule the work.

As a result of the methods briefly discussed, many advantages have occurred:

The superintendent has time in which to meet customers and to deal with them with satisfaction.

The workmen are assigned work for which they are best qualified. There is little time occupied in determining what is to be done and in getting it done.

The customer is not annoyed by not getting his car when promised, as the schedule is lived up to in about 90 per cent. of the cases and this percentage is increasing.

The workmen are encouraged to reach higher standards and to become fitted to do a better grade of work.

The cost of repairs has been reduced.

The demands upon the shop have become more uniformly distributed throughout the day and the year. A special repair price of 30 per cent. reduction is given on all repairs made in winter months, that period when motor service is least.

These and other satisfactory results have been obtained, which serve to demonstrate that the principles of Scientific Management can be successfully applied to a shop where many variables prevail.

Campus View Purdue University.
Practical Mechanics Building in background.

WHITE SUGAR—CANE OR BEET?

By ALBERT HUGH BRYAN, '98.*

Synopsis: This paper presents the reasons advanced by one of the leading authorities on the sugar industry in this country, why beet sugar will produce as satisfactory results as those obtained from the use of cane sugar. For those readers who have been under the impression that the beet sugar is not as sweet, that it prevents the jellying of fruits, that it produces discolored "fondant," and is generally inferior to cane sugar, this article should produce a changed viewpoint.

To the layman, sugar means white granulated sugar, while to the chemist it also signifies the sugar, sucrose, which is the predominant sugar in ordinary white sugar. Common usage, covering many years, has added the word "cane" to the word "sugar" from the fact that the tropical or semi-tropical sugar cane produced all of the sugar of commerce. In later years the words "Cane Sugar" have been applied also to the white sugar produced from sugar beets, since the two products seemed identical.

Today it is an open question whether the terming of beet white sugar as cane sugar is correct; especially is this so when one considers that white sugar from beets is quoted at from 10 to 20 cents per 100 pounds less than that made from sugar cane, and also in view of the fact that many users of beet sugar claim that it is inferior to cane sugar. This, however, is a question of labelling under the various pure food acts.

The various views held regarding beet and cane by users of sugar are interesting and I desire to present a few of these, trying to show their relations to the product.

Chemically considered, white sugar from these two sources contains practically the same percentage of sucrose, viz., 99.5% to 99.8%; the same percentage of moisture, viz., .05% to .20%; the same percentage of mineral matter, viz., .05% to .20%, and the same percentage of undetermined matter, viz., .05% to .20%. Then it would be reasonable to believe that they have the same sweetness. However, there are persons who claim that beet sugars are less sweet than cane sugars. The sweetness of a product is due to the substance itself and also to the quickness of solution in the mouth. The ease of solution is regulated to a great extent by the hardness of the crystals of the sugar. A manufacturer can easily regulate the temperature of "graining" and finishing, thereby producing a hard or comparatively soft crystal, so one can reason back that beet white sugar and cane white sugar of the same degree of purity should not differ in sweetness.

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As regards color of the sugar, some claim they can distinguish one from the other by this means. At the start of the beet sugar industry, the policy seemed to be to produce a sugar that would be merchantable with no idea of standardizing the color, grain, etc. As a result it became popular practice to "blue" the sugar so as to make a marketable white sugar. In doing this, many times the product was so heavily "blued" that on solution in water the insoluble blue (ultramarine) came to the surface as a scum. This then led users to claim that beet sugar was always heavily blued and thus inferior. Partly on account of this trouble, and also on account of food laws, the practice of blueing of sugar, especially in such noticeable quantities, was stopped. Today when blue is used, it is in very small percentages. Users of blue claim that a dead white sugar is livened by blue and it does not conceal any inferiority in the product; hence they argue for its use. In a general way, the color of a sugar is regulated by the size, evenness and clearness of the crystals. All of these can be regulated in the boiling of a sugar, so one would not expect to find any striking differences between white sugar from these two sources.

Another contention of users of sugar, especially among makers of jellies, marmalades, etc., which seems to have little weight, is this: that beet sugar prevents the jellying of fruits, also with its use there is a larger percentage of loss by fermentation in the finished products. The jellying properties of a fruit juice are due practically wholly to its pectin content. If this is not sufficient or if the bodies forming this general class are not correct ones, no fruit juice will congeal. Commercial manufacturers often treat fruit juice with phosphoric acid or some other acid to change these pectin bodies into the proper form or condition to produce a jelly. Sugar seems to play no part in this system. As regards fermentation, if a certain sugar produces a fermentation in fruit, this evidently is due to contamination of the sugar after it leaves the factory and is not an inherent quality of the sugar, for in the course of manufacture of the two products the temperature, which is high, is practically the same in beet and cane work. The other point often made in this connection, viz., that with beet sugar the finished jelly or preserves will show more crystallization of sugar than when cane sugar is used, may or may not have weight. Crystallization in the finished product is due to a supersaturation of sugar. This supersaturation is just as liable to occur with beet as with cane sugar if too much sugar has been used. If, however, the fruit juice was acidic, thus causing a slight inversion or breaking down to the simple sugars, dextrose and levulose, during the boiling, the use of one lot of sugar might show crystals in the finished product more than with another lot, due to the neutralization or partial neutralization of the acid by the salts or ash in the sugar. That the quantity of ash does influence the results is evidenced when making commercial invert sugar by heating sugar with a very small percentage of acid, in that certain sugars take much more acid than others to produce the same degree of inversion with the same heat in the same time. For inversion processes, then, a variation in the content and kind of ash may play an important part in the manufacturing of a product. One, however, seldom considers the ash content of white sugars as an important determination. As to whether or not beet sugars contain, as a rule, more ash than cane and hence are not interchangeable in these manufacturing processes, no one can say off hand, as there are not sufficient results available.

The candy maker is often heard to say that he cannot use beet sugar in making "fondant" or hard white candies for the reason that the product is always colored, generally yellow or brown. This darkening, which is evidently produced by the heat necessary for concentration, is due to the class of substances we speak of as undetermined in our general analysis. This condition may also result when using cane sugar, for experimental work has shown that some lots of cane white sugars will also produce dark colored white candies. The candy maker, then, who desires white candies has either to try out experimentally the various lots of sugar that he buys or obtain certain grades for his work.

These impurities make themselves felt, or are the reason for the excessive foaming, when bringing large batches of sugar into solution in water and they cause the varying quantities and qualities of the scum noted when using varying lots of sugar. The cloudy appearance of a clear sugar syrup after standing some time is also due to these impurities. And again, certain of these unestimated impurities may be the cause of the bleaching of the delicately colored fruit when preserved in sugar syrup, which is more noticeable at one time than at another. Whether these conditions are greater when using white beet sugar than when using cane sugars needs further careful demonstration.

These considerations, however, should open a new field of research which might lead to a more careful sugar manufacture and to a more careful and extensive examination by the chemist of the individual lots of sugar.

In closing, there is one point in this contention that often goes unchallenged, viz., that beet sugar abroad is used almost wholly for all purposes without any of these troubles. Hence, American beet sugar should do the same. In the United States beet sugar is made direct from the sugar beet with a single crystallization, while abroad *raw* sugar is made direct from the beet and this is dissolved, treated in the refining process, then crystallized; hence, it is the product of a second crystallization. Second crystallization should yield a purer product. It may or may not, but it does give a different composition of impurities in that class of undetermined matter which the chemist of today seldom investigates. The American cane sugar today is, with the exception of a small amount produced in Louisiana, the result of a double crystallization or has been made into raw sugar and then refined.

COASTING RECORDERS FOR CHECKING ELECTRIC CAR OPERATION EFFICIENCY

By C. C. CHAPPELLE*

Synopsis: Explaining how Coasting Recorders for checking electric car operating efficiency have brought about net savings of from $50.00 to $200.00 per year, and how the most efficient car speed as well as the motorman's pay time is obtained from the Coasting Recorder card.

The analysis of the fundamental principles† involved in operating any given car and its equipment, of given gear ratio, under given conditions, establishes the following:

(a) Efficiency in the operation of a given electric car and its given equipment is solely dependent upon the efficient utilization of certain controlling time-element factors.

(b) The efficient utilization of these time-element factors is measured by the coasting time and the per cent. coasting, for the varying conditions encountered in practical operations.

(c) For any existing or adopted schedule speed, on any electric railway, increase in the coasting time means increase in efficiency and a schedule speed to be economical must permit of possible coasting time.

(d) For a given car and its equipment, there is a most economical schedule speed, dependent upon traffic conditions and the relative unit costs for power and platform labor expenses; such economical schedule speed has a corresponding resultant per cent. coasting; if the schedule speed approaches the economical schedule speed for the traffic conditions, the corresponding resultant per cent. coasting shows relatively slight variations for the ranges of traffic conditions usually encountered in practical operations.

From the foregoing it is apparent that the per cent. coasting, determined by measuring the coasting time, is the correct relative measure of efficiency in car operation under conditions encountered in practice and that the per cent. coasting is the proper basis for a correct method efficiency checking system.

The Rico Coasting Recorder (Fig. 1) is essentially a clock mechanism of simple and rugged design, so constructed and connected by suitable electric relay with the car wiring and brake equipment as to measure and print the time during which the car is in motion with "power off" and "brakes off," or in other words the coasting time. From the coasting time the per cent. coasting, i. e., the ratio of the schedule time to the coasting time is determined. The Rico Coasting Recorder, therefore, meets the requisites for a correct efficiency checking system.

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† For the analysis of these principles, the reader is referred to an article, by the author, in the Electric Railway Journal, Jan. 15, 1916, entitled—"Fundamental Principles of Car Operation Efficiency."

The results obtainable in practical operations by the Rico Coasting Recorder utilized as an efficiency checking system may be summarized as follows:

I. **EFFECT ON POWER:**

1. **A saving in power consumption; the percentage of saving in power being approximately directly proportional to the increased percentage of coasting. (See Table I.)**
2. **A lowering of the peak on the power station.**
    - a. **Due to the decrease in average power consumption per car per hour of operation.**
    - b. **Due to the motorman's time in accelerating the car becoming more uniform and approximating the calculated acceleration time, based on the motor equipment characteristic performance for the established schedule speed and traffic conditions.**

II. **EFFECT ON BRAKE SHOE MAINTENANCE:**

Due to saving in direct brake shoe wear. As the energy to be dissipated in brakes varies as the square of the speed at the time of applying the brakes, therefore, as a portion of the energy stored in the car is utilized in coasting, the speed at the time of applying the brakes is less, with a resultant reduction in the energy to be dissipated by the brakes.

III. **EFFECT ON EQUIPMENT:**

1. **Decrease of armature and other motor troubles due to smaller rise in temperature, resulting from lower average amperes passing through the motor.**
2. **Decrease in wear and tear on equipment in general, resulting also in saving in maintenance and renewals of wheels, gears, etc.**

IV. **EFFECT ON RUNNING TIME:**

The regular running time is made more uniform per trip and closely approximates the schedule running time, due to the system of checking by the use of the Rico Coasting Recorders.

V. **EFFECT ON ACCIDENTS:**

Decrease of accident liability.

- a. **Due to lowering of maximum attained speed, hence resulting in more uniform speed.**
- b. **Due to more uniform braking.**

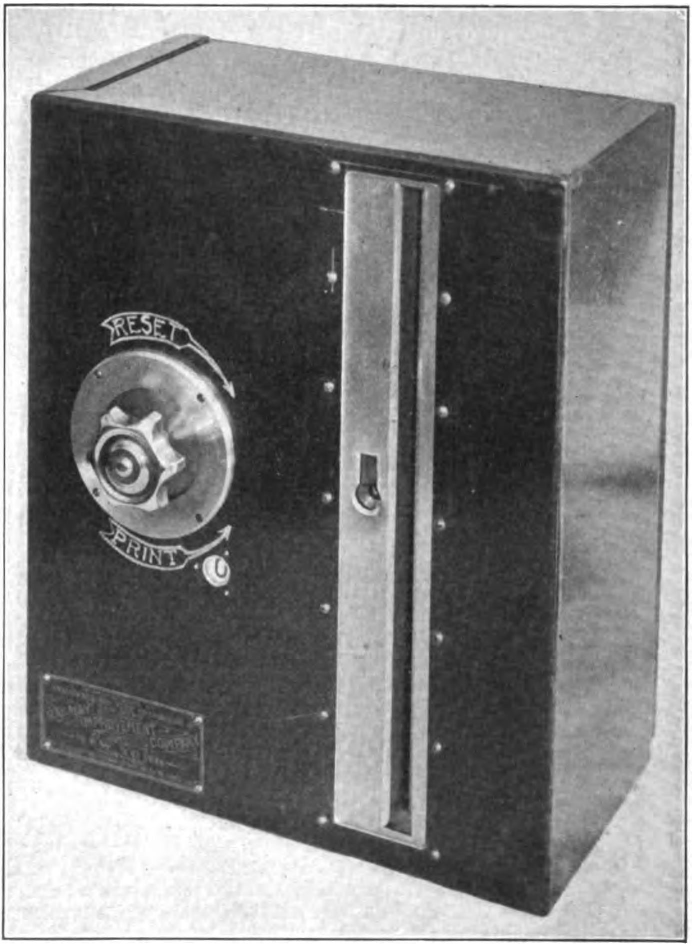


Fig. 2.

c. Due to power being on a smaller percentage of the time, thus leading to one less operation to stop or reverse the car as necessity may demand.

d. A motorman to obtain maximum coasting time must at all times be on the alert to avail himself of all opportunities; therefore, as a natural deduction the motorman ceases to be an automaton. He becomes a thinking operator on the alert at all times. Hence under these conditions accidents to pedestrians and traffic vehicles will diminish.

The consideration of the principles involved in the attainment of car operation efficiency shows that all the time-element factors, determining and controlling efficiency are not within the control of the motorman. For illustration, the motorman has only part participation in the resultant duration of stops, and the schedule speed and number of stops are wholly determined by others and by the traffic conditions.

The attainment of possible efficiencies in car operation means in practice not only improvement in the efficiency of the motorman, for any existing schedule speeds and traffic conditions, but also means the accomplishment of additional attainable efficiencies through economical schedule speeds based on the analysis of the accurate record of traffic conditions for each hour and minute of each car on every line or route of a railway system.

The Rico Coasting and Service Recorder (designated for commercial abbreviation Rico C. & S. Recorder) is a recent development, based on the essential features of the Rico Coasting Recorder, modified in design to give in printed card form the essential factors encountered in practical operations effecting car operation efficiency. Figs. II, III and IV show respectively exterior and interior views and facsimile of record, of the Rico C. & S. Recorder.

Referring to Fig. IV, from left to right, the form card record shows for each trip of a run or between any designated points for which the information is desired, the following:

Column S. The record of the total number of stops.
Column S. T. The record of the aggregate total time in minutes consumed by the total number of stops.
Column C. T. The coasting time in minutes.
Column R. T. The actual total running time in minutes, including in such total the aggregate stopping time. (Column S. T.)
Column Badge No. The badge number of the motorman operating the car when the record was obtained.
Column Car No. The number of the car on which the record was taken.
Column Trip No., at the extreme right, is self-explanatory. It acts as a guide and gage to the motorman for placing the records consecutively on the form card.

The columns S., S. T., C. T. and R. T. are totaled for the motorman's daily operation and entered as indicated.

The form card can be arranged with space at the bottom, as shown in Fig. IV, for entry by the time clerk of the motorman's pay time, for the day. This entry can be made by the time clerk, or by an automatic time clock, showing the day of the month and the motorman's exact time on and off duty, leaving only the footing of his automatic record of pay time to be entered by the time clerk, as shown on Fig. IV. This particular motorman's total pay time for November 25, 1915, was 580 minutes or 9 hours and 40 minutes for the day.

The Rico C. & S. Recorder, it is apparent, possesses all the advantages and results obtainable from the Rico Coasting Recorder, but it also makes available for utilization in the determination of economical schedule speeds and for analysis of the equities of standards for service, the constant, accurate and automatic record of the vital factors of varying traffic conditions.

The operations required to obtain the record are quickly made and "fool-proof." In making the record, all the type dials return to zero position for each dial after making each trip or desired period record, thus facilitating the clerical work required in making any desired footings for analysis. As the record is on a card, it is more convenient for handling, reference and preservation than the tape form record used in the Rico Coasting Recorder.

With the Rico C. & S. Recorder record available, the correct measure of the motorman's efficiency is not only shown by his per cent. coasting, but the data are available to check his actual efficiency with the obtainable efficiency for the schedule speed under the recorded traffic condition factors.

The Rico C. & S. Recorder removes the construction of economical schedule speeds from the realm of experimental determination and guess-work, as the data are available for the schedule builder to determine the economical schedule speeds which will fit the available equipment for the actual traffic conditions.

The Rico C. & S. Recorder records make available the data for determination of the suitability of the gear ratio of the equipment from the record of the traffic condition requirements.

The records of the number of stops and duration of stops, in connection with the passenger record data, can be utilized to determine the efficiency in practical operations of entrance-door designs, step heights, seating arrangements, etc., thus giving definite data for determining their adoption.

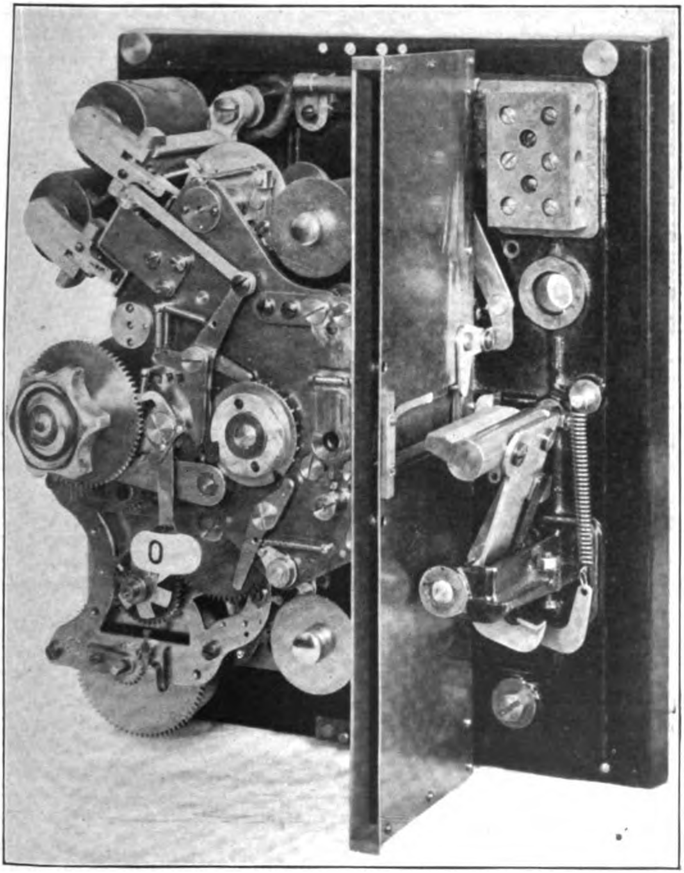


Fig. 3.

Similarly, the adaptability and advantages of high efficiency bearings, methods for lubrication, etc., can be checked, having the schedule running time, coasting time, etc., obtainable therewith in automatically printed record from the car or cars so equipped for comparison with similar records on the existing car equipment.

The consideration of the record (Fig. IV) from the Rico C. & S. Recorder will doubtless suggest to operating executives its availability for checking many other features encountered in practice.

The result of interest to the operating executive staff of a railway is the largest practicable reduction of power at the source of supply, where the cost of power originates. Such result can be obtained only by a constant and consistent checking of the motorman's efficient utilization of the controlling time-element factors.

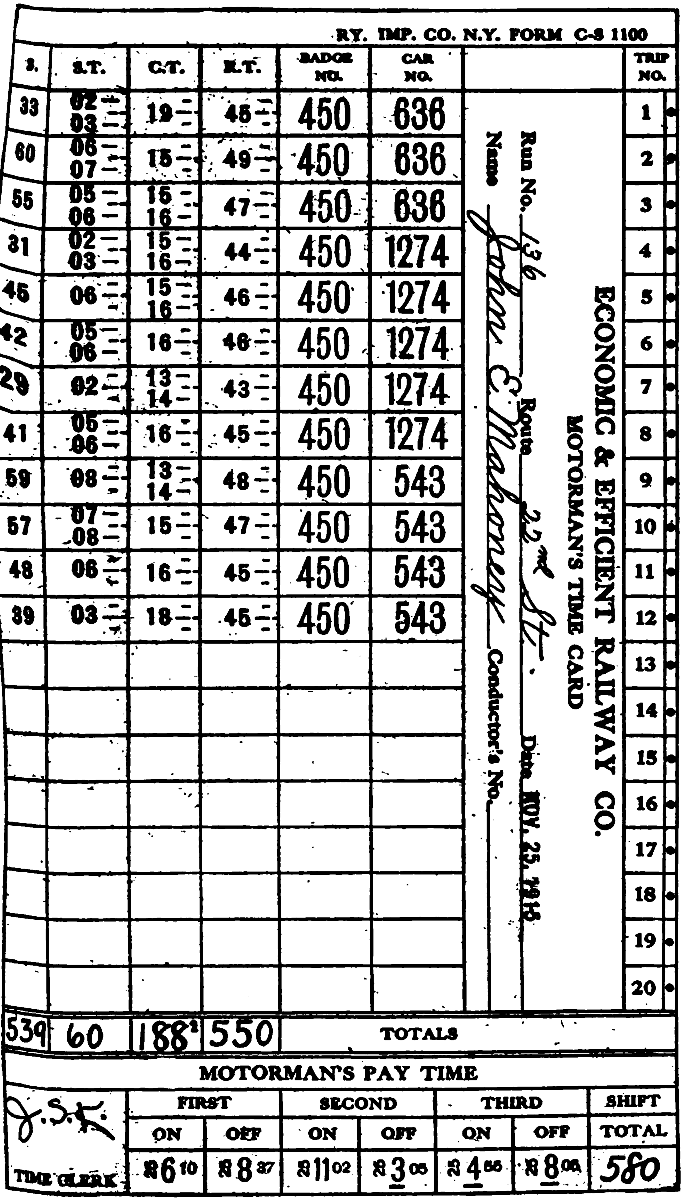
The efficient utilization of the controlling time-element factors is relatively correctly measured for any and all conditions of practical operation by the coasting time; any increase in coasting time (with schedule speed maintained) means more efficient utilization of the controlling time-element factors and consequently a reduction in power.

When equipped with the Rico Coasting Recorder or Rico C. & S. Recorder Efficiency Checking System, the motorman (maintaining schedule speed) has to deal only with the increase of his coasting time, which is automatically recorded in printed form for each trip. Thereby, he obtains the correct relative measure of existing efficiency—a guide and monitor for him and record data for the executive staff to compare with possible efficiency.

The operating results of more than 8,000 cars (on thirty-seven railways) whose operations are checked with the Rico Coasting Recorder efficiency checking system, are available. These results show 10% to 25% reduction in the power used for traction purposes, 15% to 45% reduction in brake shoe maintenance and a material though less tangible reduction in motor equipment maintenance and accident liability.

The results obtained by railway companies utilizing the Rico Coasting Recorder efficiency checking system, show net savings, after deducting maintenance and operating expenses for the Rico equipment, ranging from $50.00 to $200.00 per car per year, dependent upon the conditions of operation, the cost of power, etc. The analysis of results obtained in practice indicate that for the conditions of the average company, approximately the entire cost of the Rico Coasting Recorder equipment can be saved each year of its operation. The utilization of the Rico C. & S. Recorder now offered for commercial use should make possible even greater net savings.

Nearly two score of electric railways utilizing the Rico Coasting Recorder as an efficiency checking system, represent the widest possible range of topography, of speed, of congestion in traffic, car and train service, and of labor conditions.



RY. IMP. CO. N.Y. FORM C-S 1100

ECONOMIC & EFFICIENT RAILWAY CO.

MOTORMAN'S TIME CARD

Run No. 136 Route 22nd St. Date NOV. 25, 1915

Name John E Mahoney Conductor's No.

S.	S.T.	C.T.	R.T.	BADGE NO.	CAR NO.	TRIP NO.
33	02 03	19	45	450	636	1
60	06 07	15	49	450	636	2
55	05 06	15 16	47	450	636	3
31	02 03	15 16	44	450	1274	4
45	06	15 16	46	450	1274	5
42	05 06	16	46	450	1274	6
29	02	13 14	43	450	1274	7
41	05 06	16	45	450	1274	8
59	08	13 14	48	450	543	9
57	07 08	15	47	450	543	10
48	06	16	45	450	543	11
39	03	18	45	450	543	12
						13
						14
						15
						16
						17
						18
						19
						20
539	60	188^{1}	550	TOTALS		

MOTORMAN'S PAY TIME

	FIRST		SECOND		THIRD		SHIFT
J. S. F.	ON	OFF	ON	OFF	ON	OFF	TOTAL
TIME CLERK	25 6^{10}	25 8^{37}	25 11^{02}	25 3^{05}	25 4^{55}	25 8^{05}	580

Fig. 4.

The success and practicability of the Coasting Recorder, therefore, is independent of local physical and operating conditions. It is easier to create than to maintain enthusiasm; the Coasting Recorder not only creates but maintains enthusiasm.

TABLE I

The Ratio of *increase* "Per cent. Coasting" to *decrease* "Per cent. Power" has been determined by carefully conducted tests, under actual conditions of operation, upon metered sections or systems of several typical railway companies, covering widely divergent operating conditions, as follows:

NAME OF ROAD	Ratio of Increase Per Cent. Coasting to Decrease Per Cent. Power
San Francisco-Oakland Term. Rwy.	1%—1.22% Saving
Denver Tramway Company	1%—1.1 % Saving
Pacific Electric Railway	1%—1.06% Saving
Met. West Side "L"—Chicago	1%—0.98% Saving
Bay State Street Railway	1%—1.05% Saving
Washington Railway & Elec. Co.	1%—1.02% Saving
Northern Texas Traction Co.	1%—1.2 % Saving
Los Angeles Railway Co.	1%—1.07% Saving
Empire United Railways	1%—0.78% Saving
Milwaukee Elec. Ry. & Lt. Co.	1%—1.07% Saving
San Antonio Trac. Co.	1%—0.99% Saving
Boston Elevated Railway Co.—Surface	1%—1.09% Saving
Elevated	1%—0.94% Saving
Syracuse Rapid Transit Co.	1%—1.19% Saving
Interborough Rapid Transit Co.	1%—0.91% Saving
Chicago Rys. Co.—(Surface)	1%—0.91% Saving

The above ratios obtained from actual tests appear slightly higher than the ratios indicated from several Speed Time and Power Diagram analyses. It should be borne in mind, however, such analyses assume constant voltage conditions, while in practice the decreased power resulting with coasting causes less voltage drop and hence corresponding improved voltage conditions, with consequent improved changes in the motor performance for such actual conditions of operation, thereby probably resulting in a higher ratio obtainable in actual operation.

PLANS OF THE AMERICAN ASSOCIATION OF ENGINEERS

By A. H. Krom, '10*

Synopsis: An article presenting the efforts of the American Association of Engineers to raise the standard of ethics of the engineering profession, and to promote the economic and social welfare of engineers.

In the early part of December, 1914, a few Chicago engineers met to discuss the Economic Problems of the Engineer, the principal topic being that the average engineer was underpaid and that a strong organization was necessary in order to gain proper recognition. Within a short time many representative engineers from all branches of the profession were interested and the study of this great movement was taken up through well directed energy by means of a temporary organization until our charter was received from the State of Illinois in May, 1915. Many valuable ideas were gained from the records of the "German Society of Technical Men Employed in the Industries," and our plans as well as the number on the membership list became greater until a great speed was gained for the movement during the three months previous to the First National Convention in December.

The subject of ways and means to bring about a greater appreciation of the engineering profession and the services of the engineer to the community and to the nation has been given increasing attention during recent years and has been discussed at meetings of the various engineering societies and in the technical press. Due to the size of this professional task, the other societies which are busy with their respective technical problems, have not undertaken this great work, therefore it remains for this body of all engineers to take up the "human" problems and to advance the material and social welfare of engineers as a profession.

It is a well known fact that, while wages and salaries in practically every other line of work, from day laborer to bank president, have increased greatly within the past few years, there has been no similar rise in the compensation of engineers. The salary of the average detail engineer is less than that of the average union tradesman, or skilled mechanic, while on the other hand he is forced to live on a higher social plane, so that his expenditures are almost equal to his income. Now let every technical graduate be fair with himself! What return above a fair living are you making on your engineering education, if you consider it as a business investment?

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*Engineer in charge of the Chicago Office, State Public Utilities Commission of Illinois.

It is to correct this condition of affairs and to render other equally important services to the profession that this Association was formed. The keynote of success is co-operation.

The American Association of Engineers will be devoted to the best interests of the average engineer of good standing. Not to elevate the already elevated but to bring up the standing of the rank and file to that attained in other professions. We solicit the support of the professor, the big engineers and employers of engineers and aim to command their respect through our services and objects and in the course of due time secure the same standing for the engineering profession as that enjoyed by the legal, medical and military professions—material compensation, consideration, and self-respect.

Our objects are: To raise the standard of ethics (stop knocking—begin boosting by co-operation) of the engineering profession and to promote the economic and social welfare of engineers:

1st. By affording means for the interchange of information—read the standard publication, "The Monad."

2nd. By maintaining a national service clearing house for engineering service, where each member will be classified as to education, training and experience by the Qualifications Committee and employers may refer their wants in the technical vocations to our Secretary who will send out confidential notices to all men who are qualified. Employers will be listed and members may make application for employment directly or through the Secretary. New work in all lines will be carefully listed in the Secretary's office and all important undertakings which require men skilled in the various arts will be printed in "The Monad" or its supplements, which each member will receive. New positions will be created by direct efforts of the Association's representatives.

3rd. By affording patent and legal advice—a new field for associated effort. Few technical men fully understand the constitutional rights of inventors; what a patent right really is or what rights an employer has in connection with development work performed by his employees. Valuable education in this direction may be gained from the Association and its publications.

4th. By supervision of legislation—an activity of the greatest importance, not only to the men engaged in professional work of a technical character but to the public in assisting legislators of the various state, municipal and national bodies to treat big subjects with scientific enlightenment and to place men who have technical ability in charge of all public enterprises where technical skill will apply to gain greater safety, economy and capacity for public welfare. Incidentally, the result will be to clear the field of its incompetents who infest political places and secure those places for the qualified engineer.

5th. By proper publicity. To educate the public is no easy task, but if every man will co-operate with the press bureau and at the same time be a walking disciple for the cause of being a living illustration of competent intelligence, worthy of better recognition, the result is bound to be elevation of the standards by which we are to be gauged—socially and financially.

The American Association of Engineers being primarily an association to gain better recognition for the technical profession must base its activities upon the personal qualification of its individual members.

Associate membership is given to all of those who are not directly engaged in technical pursuits, or those who may have a desire to assist in the elevation of the profession in other directions than the Certification and Employment Promotion (Service Clearing House) Departments.

Certified membership, according to our Constitution, may be extended to any citizen (or one who has taken oath of intention to become a citizen) of the United States of America, of good moral character, who is engaged in any branch of the sciences or technical arts, who shall be a graduate of any recognized technical school or college, who shall have had not less than two years' practical experience subsequent thereto, or who shall in lieu thereof, have had five (5) years' practical experience in engineering work. It is assumed that the applicant who has five years' practical experience as an engineer must have acquired sufficient technical knowledge to enable him to fill his position to the satisfaction of his employer.

The Monthly Bulletin will in addition to giving a review and listing the technical articles appearing in Trades and Scientific Journals, devote a large part of its space to an outline of interesting achievements of its members and their employers with a view to promoting their interests individually and collectively. This Bulletin will also present papers written by our members on subjects of professional ethics, patent law and comments on evils, uncomplimentary and unjust conditions which may exist in the industries, educational institutions and civic organizations where the technical profession is affected, from the position of draftsman to consulting engineer. No attempt will be made to regulate or stipulate salaries of members, but where practical, rates for consulting services and classified engineering work such as investigations, researches, analysis and estimates of costs requiring professional services to the general public will be classified and schedules of adopted minimums will be issued for the benefit of both the public and the profession at large.

To summarize the certification of engineers by the A. A. E., it is the fundamental channel through which we will elevate the standard of both compensation and ethics of the profession:

First: By establishing and demonstrating the recognizable worth of engineers in the various fields of industry.

Second: By eliminating the mediocre incumbent of positions requiring engineering skill and substituting therefor men of such ability as will redound to the elevation of the engineering profession through the element of efficiency.

Third: By assisting men with engineering qualifications into positions where their skill will become productive and recognized.

Fourth: By associating in a co-operative spirit and willing action, shedding upon the world a light representing usefulness to ourselves as well as to the industries to which engineering is but a servant in the interest of a better world.

In conclusion, the seven following features as printed by the Chicago daily papers might be noted:

1. Formed 6 months ago by 300 Chicago engineers drawn from the various engineering departments of the City of Chicago, State and Federal governments as well as those large industrial enterprises employing engineers in Chicago as for example the railroads, electric light, telephone companies, etc.

2. Formed for the purpose of bringing a closer relationship between the employer of engineers, the employee and the public. *Example*: Six or seven of the large rail

roads entering Chicago are spending millions on improvements, of which the public knows little and about which as citizens they ought to be better informed. This is due to the fact that the newspaper man can not be expected to understand technical problems and hence is not interested enough to cover the job. The American Association proposes to prepare such information periodically for the press as they will use in regard to big construction in the various parts of the United States. In Chicago in particular there are 25 to 30 big construction projects which the laymen public would be more interested in knowing than they would in the large space alloted to atrocities.

3. This is the first national engineering organization in the United States to have as members engineers drawn from all fields, such as civil, mechanical, electrical, chemical, etc.

4. This is the first national engineering organization in the United States to take up the welfare of the engineer and to try and put the engineer in touch with the job and the job with the engineer free. They have placed 100 men with jobs ranging up to $6,000.

5. This is the first national organization in the United States to attempt to make a stand against the policy of political machines appointing doctors, dentists, butchers, and barkeepers to engineering positions requiring the skill and exercise of mature and seasoned technical judgment.

6. This organization already has chapters in the process of formation in 19 cities. The seed is being sown, and the product, it is hoped, will mean a membership of 20,000 engineers by June, 1916. There are 100,000 engineers of all branches in the United States. The largest national organization for one branch alone is the American Society of Civil Engineers with about 7,500 members.

7. During the First National Convention held in Chicago, December 10 and 11, amendments were made so that engineering students may obtain Junior Memberships and receive practical business training while in school, and then after two years' experience in the profession, they can gain full memberships without the payment of an initiation fee.

EXPANSION AND CONSTRUCTION JOINTS IN REINFORCED CONCRETE VIADUCTS

By A. B. Cohen, '05*

Synopsis: Are expansion joints necessary and on what types of concrete construction?
What has been the experience of the D. L. & W. Ry. with expansion joints on the several large viaducts recently constructed on their system?
These questions and others pertaining to the details of expansion and construction joints, Mr. Cohen answers in this article.

Second only in importance to the determination of the most economical sections in reinforced concrete design of any magnitude, is the detail of expansion joints and following this consideration closely, is the location of the construction joints. These details are so important that it sometimes becomes necessary to waive economic considerations in order to properly provide for stresses due to temperature changes; to proportion sections for construction consistent with the daily capacity of the plant thus precluding the possibility of stopping work at a critical point that would impair the strength of an important member.

Expansion joints are unnecessary in bridges of about one hundred feet in length. The slight movement due to temperature changes is taken up by the elasticity of the structure. For greater lengths, the movement due to these changes becomes appreciable and owing to the low tensile strength of concrete, expansion joints dividing the structure into smaller units are necessary to prevent dangerous and unsightly cracks.

There is, however, a type of reinforced concrete construction known as the flat slab system which has been used for viaducts of great length without resorting to expansion joints. Eighteen and one-half acres of ground were covered by this type of design in the construction of the "Soo Line" Terminal at Chicago. The Delaware, Lackawanna & Western Railroad has just completed a combination viaduct and station of similar design, in eliminating the grade crossings by track elevation through South Orange, New Jersey. This system has also been adopted for an elevated structure supporting seven tracks in the Lackawanna Terminal improvements now under way at Buffalo, New York. The structure will be 150 feet in width and 1,000 feet in length.

The flat slab system consists of a slab of uniform cross-section, supported on columns forming panels 20 to 30 feet square. There are no beams or girders and the loads are carried from the slab directly to the columns. Because of the uniform cross-section, the slab can be effectively reinforced for changes in length due to temperature variations, by inserting steel bars to maintain a constant tensile strength throughout and particularly across the construction joints. Since steel and concrete have approximately equal rates of expansion, no amount of steel would prevent cracks resulting from the temperature changes. The steel, however, prevents cumulative action of the stress at any particular section and distributes the strain uniformly, resulting in an infinite number of minute cracks. Our experience with this type of construction does not extend over a sufficient length of time to ascertain definitely what effect the repeated action due to temperature changes will eventually have on the strength of the structure. Very close observations of existing structures of flat slab construction without expansion joints have disclosed no deleterious effect due to these causes.

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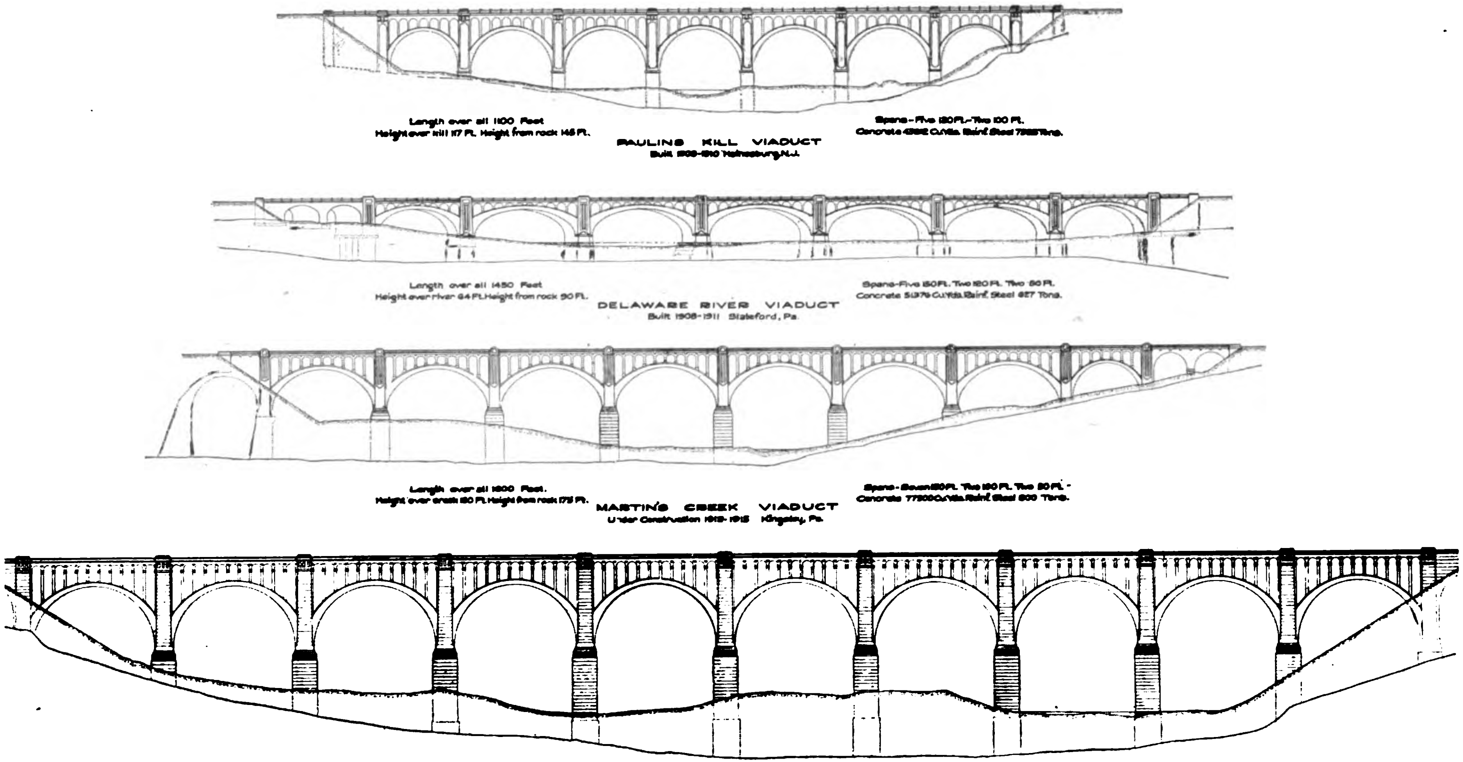
*Engineer of Concrete Design, Delaware, Lackawanna and Western Ry., Hoboken, N. J.

In concrete viaducts consisting of a series of arches, surmounted by transverse spandrel walls supporting a floor system, or in viaducts of the column, beam and slab design, the temperature changes are of more vital consequence. In the case of the beam and slab design, the constituent members have different sections and therefore offer varying degrees of tensile resistance. There arises the difficulty of transferring the movement due to temperature from the larger through the smaller members, as from the deep beams through the thin slabs. In the arch type, the very appreciable vertical movement of the heavy arch ring, for a rise and fall of temperature, is transferred to the comparatively light floor system, which must also resist its own movement in a horizontal plane. These movements cannot be resisted by the addition of any amount of steel, and expansion joints must therefore be provided.

In 1911, the Delaware, Lackawanna & Western Railroad completed two large concrete structures known as the Delaware River and Paulins Kill viaducts (see plate 1) on a 28-mile revision of the main line across the western part of New Jersey. In connection with the design of these structures, after an extended investigation had been made of existing structures of similar type, it was decided to construct the viaducts without expansion joints in the floor system. No precise data could be obtained at that time



Length over all 1100 Feet
Height over kill 117 Ft. Height from rock 145 Ft.
PAULINS KILL VIADUCT
Built 1908-1910 Hainesburg N.J.
Spans - Five 120 Ft. - Two 100 Ft.
Concrete 42812 Cu.Yds. Reinf. Steel 7385 Tons.

Length over all 1450 Feet
Height over river 64 Ft. Height from rock 90 Ft.
DELAWARE RIVER VIADUCT
Built 1908-1911 Slateford, Pa.
Spans-Five 150 Ft. Two 120 Ft. Two 80 Ft.
Concrete 51376 Cu.Yds. Reinf. Steel 627 Tons.

Length over all 1600 Feet.
Height over creek 150 Ft. Height from rock 175 Ft.
MARTIN'S CREEK VIADUCT
Under Construction 1912-1915 Kingsley, Pa.
Spans - Seven 150 Ft. Two 100 Ft. Two 80 Ft. -
Concrete 77300 Cu.Yds. Reinf. Steel 800 Tons.

Length over all 2375 Feet.
Height over creek 240 Ft. Height from rock 300 Ft.
TUNKHANNOCK CREEK VIADUCT,
Under Construction 1912-1915 Nicholson, Pa.
Spans - Ten 180 Ft. Two 100 Ft.
Concrete 167000 Cu.Yds. Reinf. Steel 1140 Tons

D. L. & W. R. R.
CONCRETE VIADUCTS
SCALE

Fig. 1.

concerning the extent of the seemingly small rise and fall of the existing arches. It was thought that most of the cracks, attributed to temperature changes, were due to shrinkage of the concrete in the first few months of construction and that if the viaducts with foundations carried to rock were built in such a manner as to minimize this action, the expansion joints could be eliminated.

The plan and sequence of construction were outlined in the following manner: the main arch rings were built in voussoir blocks about ten feet in length measured along the axis of the arch ring and spaced two feet apart. The blocks were allowed to set seven days before the two foot openings or keys were poured and twenty-eight days after the last key was poured the arch center was removed. This eliminated an undue settlement of the arch ring due to shrinkage and the theoretical crown elevation for which the arch was designed was further insured by cambering the arch center for its deflection under the ring load. No part of the floor system was built until the arch centers had been removed. The floor was built in alternate sections, but the reinforcing steel in the slab was continuous for the full length of the viaduct, which, in conjunction with the elasticity of the superstructure, was deemed adequate to resist the rise and fall of the arch ring without the formation of large cracks. It was expected that a number of small cracks would result from this movement, but these were not considered so objectionable as the leaky expansion joints that were in evidence on most of the structures inspected.

An examination of the Delaware River and Paulins Kill viaducts, after they had been in service for some time, disclosed the fact that large transverse cracks had formed at the crown of each of the two spandrel arches adjacent to every pier of the viaduct. This indicated that there had been a drop of the main arch rings due to fall in temperature. (See Plate II). Over the crown, the spandrel arches were in compression and no cracks developed while those adjacent to the pier were in tension. It may be here noted that the floor system was built during the summer months and therefore the movement in the main arch ring due to rise in temperature, would bring the floor system back to its normal position, or, if there were a movement beyond this it would be so slight as to make its effect on the floor system directly over the crown negligible, as compared with the effect of a fall in temperature on the floor adjacent to the piers.

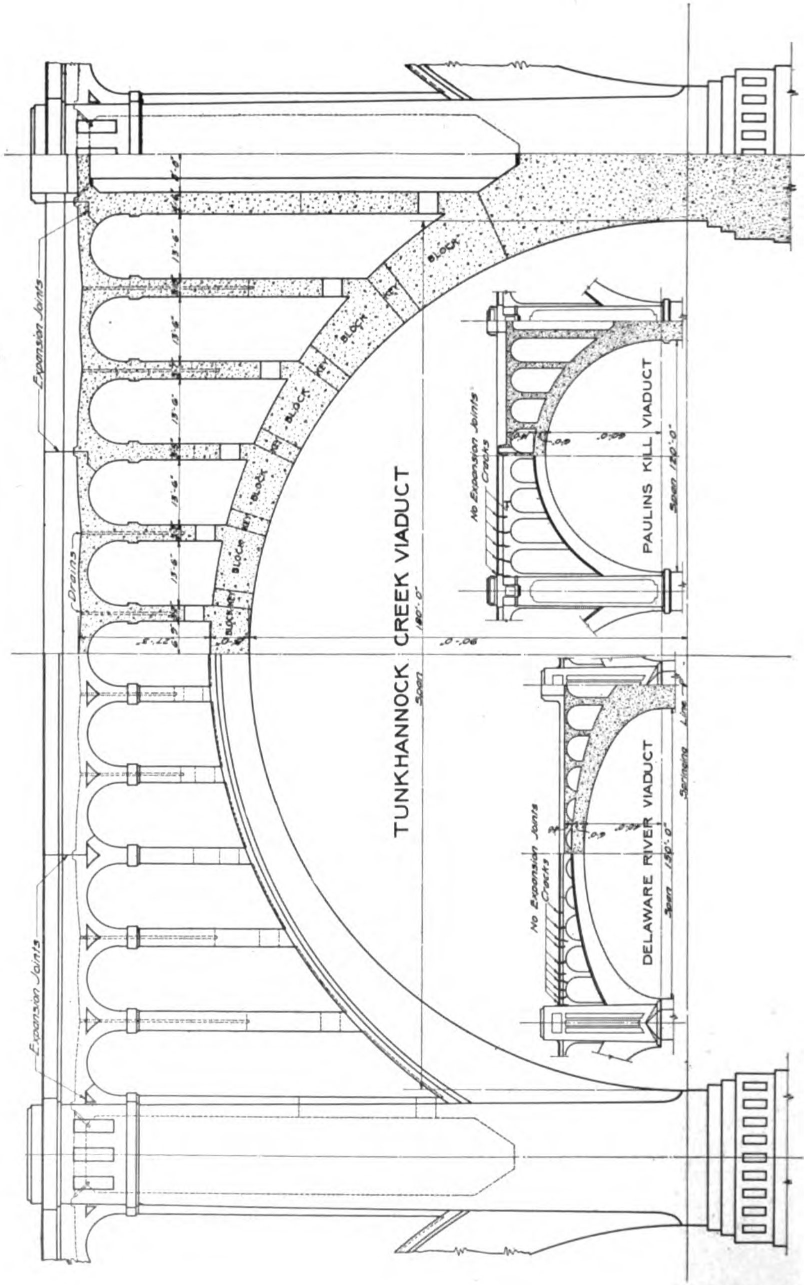

TUNKHANNOCK CREEK VIADUCT
Span 180'-0"
PAULINS KILL VIADUCT
Span 150'-0"
DELAWARE RIVER VIADUCT
Span 150'-0"
Springing Line
No Expansion Joints
Cracks
Expansion Joints
Drains
BLOCK
KEY
13'-6"

Fig. 2.

In view of the above observations, it was decided in designing the Tunkhannock and Martins Creek viaducts, recently completed on another revision of the main line west of Scranton, Pa., that expansion joints were necessary in the floor system at the piers and quarter points of every span. The quarter points of the span are approximately the points of contraflexure in the arch ring. For a fall in temperature the extrados of the arch ring between the points of contraflexure is in compression, beyond these points in tension and vice versa for a rise in temperature. The expansion joints divide the superstructure into three parts, separated at the points of contraflexure, each section acting in compression or tension as the case may be. This arrangement has proved successful for both viaducts, which have been exposed to the entire range of temperature.

In the detail of the expansion joints, it is imperative that a minimum amount of sliding surface be provided, otherwise the frictional resistance becomes greater than the tensile strength of the floor, which would cause cracks to develop adjacent to the so-called expansion joints. The sliding surfaces of the expansion joints of the big viaducts were lubricated by an asphaltic membrane. The drainage is prevented from percolating through the joints by dykes built across the floor.

As previously stated, the construction joints should be given careful consideration. It is a necessary precaution, in concrete design, to indicate the construction joints on the plans, in order to guide the foreman or superintendent who is frequently unfamiliar with the theory of design. Otherwise, a joint might be placed, for example. at a point of maximum shear, or at the junction of the stem and flange of a T beam. The massive solid piers of the Tunkhannock Creek viaduct were scored horizontally by nailing strips of moulding to the inside of the forms. These strips mark the construction joints four feet apart. Each of these sections contains 234 cubic yards, which is approximately the eight-hour capacity of a two-yard mixer. For the reinforced sections of the viaduct, the length of the reinforcing rods was so fixed that only the required lap projected beyond the construction joints, obviating the necessity of supporting dangling rods above the forms.

The precautions that were taken, to minimize the settlement due to shrinkage in the construction of the arch ring of the Delaware River and Paulins Kill viaducts, were repeated in the construction of the Tunkhannock and Martins Creek viaducts. Each main arch of these structures was built in two separate ribs. It is an interesting fact, that after the arch centers were struck, there was the slight settlement of one-quarter of an inch in one, one-eighth of an inch in three and no settlement in the other sixteen ribs.

Civil Engineering Building, Purdue University

FATALITIES AND SERIOUS SHOCKS CAUSED BY ELECTRICITY

By Geo. E. Glossop, '15*

Synopsis: This article treats in a non-technical manner of the subject of electric shock. It contains:

A classification of the injuries attributable to electricity, and their relative seriousness.

A comparison of the effect of alternating and direct current in producing a shock.

An explanation of the physiological effect of the electric current on the body, and the method of resuscitating a victim.

Time was when the mention of electric shocks suggested merely the sensations experienced in grasping the handles of the ordinary induction coil, or in receiving the discharge of a Leyden Jar. There are few persons who have not allowed an electric current to be passed through them by one or the other of the above means; and the sensation need scarcely be described. While the effect is usually of a mild and harmless nature, it is well known that shocks of an unpleasant character, even dangerous to human life, may be applied by such simple apparatus. Since electric wires are to be found overhead, underground, in nearly all buildings devoted to business, and in many of our homes, the subject of shocks is of interest to nearly everyone. With such widespread adoption of electricity for domestic and industrial use there have appeared occasionally in the public press notices of accidents due to electric shocks, sometimes attended with fatal results. These accounts, aside from the tragedy involved, are, as a rule, rather amusing to one knowing even the rudiments of electricity; all that can be learned from the daily papers is that it is safest to keep away from all wires. There appear to be proportionately few, outside those in the electric business, that seem to have any idea of what constitutes a dangerous shock, where one is likely to be obtained, and what "volts" and "amperes" have to do with it.

It is to be remembered that it is the amperes of current flowing, not in the wire but through the body, that causes the pain and the injury; the greater the number of amperes the greater the effect. Since voltage measured in volts, being somewhat analogous to pressure measured in pounds per square inch, forces a quantity of current or amperes, through the resistance offered by the human body or the wires, as pressure forces a quantity of water through the resistance of the water mains, it is readily understood that the greater the voltage the more current or amperes will flow through the given resistance. The size of the wire with which contacts are made is of little consequence; any ordinary wire can carry enough current to give a fatal shock; the number of volts does not depend at all upon the size of the wire.

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When electric current is flowing through the body a great deal of resistance is offered to the flow. The calloused palms of the working man offer the highest electrical resistance. The thick and hardened epidermis containing no blood or lymph is a poor conductor and, therefore, limits the amount of current that the man receives from the electrical circuit. However, it offers this high electrical resistance only to a momentary contact; while a continued contact will, in most instances, produce a secretion of perspiration which so moistens the skin as to give better conduction, thereby lowering the resistance. The resistance value apparently bears no relation to the height nor the cross-section of the individual but depends largely upon the resistance of the skin. When the skin has been burned through, the body resistance may readily reduce to 500 ohms. Therefore, the magnitude of the current which passes through the body is dependent upon the resistance of contact, the resistance of the body and to the conductivity of the surrounding atmosphere whether dry or damp.

The dangers peculiar to contact with electricity may be classified under four general heads. Those attributable to shocks; by shocks, meaning injuries due to the passage of current through the body. Those attributable to burns or injuries caused by burning some portion of the body that is in contact with the intense heat of an electric arc. Those attributable to flashes, or arcs, causing injury to the eyes by exposure to the intense light of the arc. Those attributable to falls caused primarily by shock or burn.

To receive a shock it is necessary that current flow into some portion of the body and out of some other portion. It is not the voltage that injures but the amount of current that is forced through the body; one one-hundredth of an ampere passing through the body will give the same sensation from a 500 volt circuit as it does from a 110 volt circuit. However, if the body resistance remains the same, nearly five times as much current will be forced through at a pressure of 500 volts as compared with 110 volts. Generally speaking, the higher the voltage involved, the greater will be the current through the body; the longer the duration of the contact, the greater the danger to life.

Burns usually accompany injury by shock, though it is possible to receive injury by a burn even where no shock is experienced. Such cases consist in the injured one coming into physical contact with an electric arc. A most annoying, though not deadly danger exists in the exposure of the delicate nerves of the eye to the intense brilliancy of an electric arc. The injury is not immediately apparent and often does not manifest itself for several hours. Eyes that have been exposed to electrical flashes become very red, due to the sudden dilation and congestion of the blood vessels of the mucous membrane that lines the lids and in part covers the eyeball. The surprise of a sudden shock, even though the shock itself is slight, may cause an unconscious contraction of the muscles, which may precipitate a man from a position otherwise secure. Such precipitation, however, assists in extricating him from what might be otherwise a dangerous contact.

There is a wide variety of external and individual conditions that influence the extent of electrical injury; individual susceptibility is a large factor, even the emotions play no inconsiderable role. For instance, there is on record that one lineman died purely of fright on touching a normally high tension line which, at the time of misfortune, carried no voltage whatever.

The experiments of Weiss, D'Arsonal, and others have enabled us to compare the respective behaviors of the alternating and direct currents. Weiss states that the alternating is about four times as deadly as the direct current. It might be thought that the danger would increase with the number of alternations, but this is not so, at least the variation of the periodicities used in the industries, varying from eleven to seventy-five cycles per second, makes no appreciable difference. D'Arsonal found that he could stand three amperes at 500000 to 1000000 alternations. This amount of current is twenty to thirty times as great as that required to kill a human being at the ordinary industrial frequency. High frequency currents, even at high pressures, are not ordinarily dangerous to life on account of their tendency to seek the surface of conductors rather than flow by way of an internal path.

Seventy to one hundred milliamperes of alternating current passing through the heart for a few seconds will cause death, whereas, with continuous current death does not occur unless about three hundred milliamperes are employed. Deaths have occurred from shocks at A. C. voltages as low as 65 and there are numerous instances of death at such pressures as 100 to 120 volts A. C. It is only under very exceptional circumstances, however, that these low voltages cause death; such as wet contact, which is equivalent to an extremely good contact, to a weak physique, and continued passage of current through a low body resistance. Although the continuous or direct current prevents more immediate danger, it may produce more lasting effects. It provokes, in the body traversed by it, actual electrical decomposition, the products of which are transported to the extremities, and this internal galvanoplasty may cause incurable injuries.

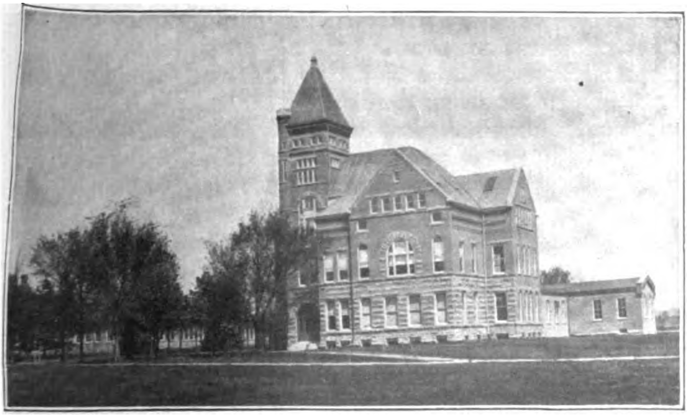
Physiological experimentation on animals adduces the conclusion that, as regards the death of human beings, it may be brought about by electric currents in several different ways. There is no doubt but that it might be due to prolonged tetanus of the muscles, which could prevent the performance of respiratory movements, and so lead to death by asphyxia. As a matter of fact, it has never apparently happened in this manner; the victim always being able either to break the contact and interrupt the passage of current for himself, or to call for help and have the contact broken by someone else before asphyxia has actually taken place. Primary heart failure is undoubtedly the most common mode of death. In this case, there is a cessation of respiration and cardiac action from electrical over-stimulation of the brain which thereby loses its power to react. This power to react is only temporarily suspended so that life, if not entirely extinct, is dependent on artificial respiration until such time as the brain recovers its power to react.

During the past thirty years a great many post-mortems have been made in cases of sudden death by electric shocks. Burns of greater or less superficial extent are generally seen at the point where the electric current has entered and left the body. In a word, the post-mortem evidence is generally negative, but may suggest asphyxia in some cases, in others organic vascular and nervous lesions in the brain and spinal cord.

It is contended by many physicians of note that if artificial respiration is immediately applied to the victim that there is much hope of recovery, particularly when the electric current has only temporarily paralyzed the nervous control of the muscles of respiration. This effect of shock is conceded to dominate in nearly all accidents where the contact was of short duration. Hope of resuscitation is, however, restricted to the proper treatment of cases of paralyzed respiration and, since deprivation of oxygen injures immediately some of the nerve centers of the brain, it is particularly important that measures for resuscitation be applied immediately and continued until natural breathing returns.

The prone pressure method of artificial respiration, which has been given universal publicity and is today taught to all employees of large corporations, consists in laying the injured on his belly with his arms stretched forward. Pressure is applied rhythmically on the loins and lowest ribs. The advantages of this method are: that the operation is simple and easy to perform, that there is no need of a second person to hold the tongue from falling back and blocking the air passages, that there is little danger of injuring the liver or breaking the ribs if pressure is gradually and not violently applied, and that a larger ventilation of the lungs is accomplished.

In general, the resistance of the human body is normally so high that, with pressures not exceeding 500 volts, accidental contacts are rarely fatal. The greater number of fatalities attend the severe burns caused by momentary contact with high voltages and falls due to the unexpected shock.



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NOTES ON ESTIMATING THE GROWTH OF CITIES

By H. G. RASCHBACHER, '04*

Synopsis: Showing how to obtain the approximate future population of a city from its past growth and its present size.

During the years 1914-1915, the writer was engaged in assisting a former classmate in preparing a report for a certain eastern city, covering the collection and disposal of all classes of municipal wastes. One of the chief questions to be determined before submitting the report was the size of the recommended plants, which in turn depended upon the quantities of the various wastes produced by the population served in 1940. The production per capita of any class of waste was easily determined by a series of complete field studies, but when the question of estimating the future population arose, few data were to be found that would furnish a reliable program for determining such an estimate. It was finally decided to plot the available census data and estimate the future population from a straight line curve. Before doing so, the writer endeavored to ascertain if there were any determinable law or laws governing the growth of cities except a mere estimate of what future conditions were liable to be. While the studies made did not attain the end for which they were carried out, a number of interesting facts were brought to light and it is felt that they are of sufficient interest to be of some value to readers of the Purdue Engineering Review.

In general the population curve for any city can be plotted by the formula, $P = M Y^n + C$, where, P is the population for any particular year, M, a numerical coefficient, Y, the number of years elapsing from the first plotted on the curve to the one for which the population is desired, ^{n}, an exponent determined from the available data at hand and C, the population of the city in the first year plotted on the curve. By substituting the data at hand for all the American cities as furnished by the Bureau of the Census in the above equation, a series of equations results for any particular city, in which P, M and ^{n} are the only unknowns. By the method of Least Squares, these can be brought to two simultaneous equations in which M and ^{n} can be determined and a resultant equation found in which P is the only unknown. By substituting in this equation for any future year the population determined will be a value lying in the curve which is the closest to passing through all the points which may be plotted from any data which may be available.

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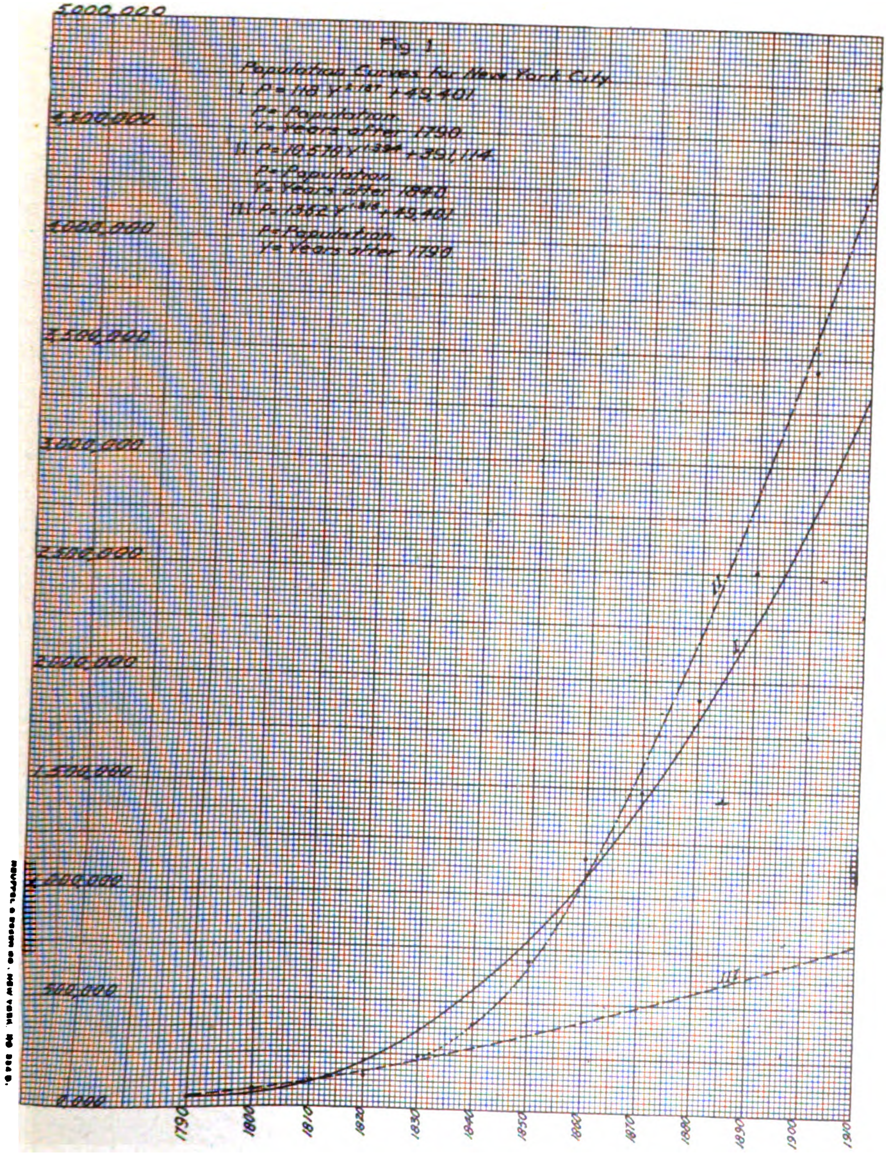
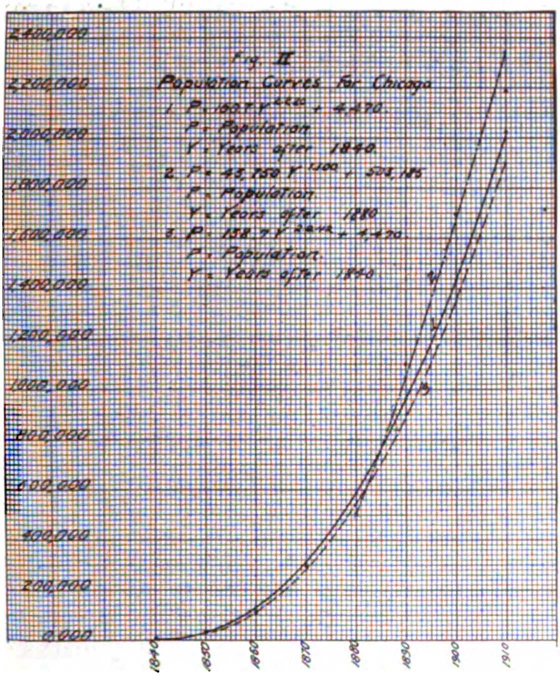


Fig 1
Population Curves for New York City
I. $P = 118\,Y^{2.187} + 49{,}401$
P = Population
Y = Years after 1790
II. $P = 10{,}570\,Y^{1.394} + 391{,}114$
P = Population
Y = Years after 1840
III. $P = 1382\,Y^{1.816} + 49{,}401$
P = Population
Y = Years after 1790
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0,000
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
I
II
III

In carrying on the studies made, population curves were worked up for the following cities: Baltimore, Boston, Chicago, Cleveland, New York, Philadelphia, Pittsburg, and St. Louis. These cities comprise the eight largest cities in the country according to the last U. S. census, they present a fairly wide geographical range, the conditions which affected their growth could hardly have been very similar and census information was available for the majority of the cities for a period of 120 years. For these reasons, it was felt that if any general law could be deduced from the information covering these cities, it would be applicable to a fairly wide range of conditions, not only as regards geographical location, but size of the city as well.

Three curves were worked out for each city listed above, and numbered 1, 2, and 3. Curve No. 1, was that curve which would most nearly pass through the points plotted for the entire period for which census data was available. Curve No. 2 was plotted from the data for all years following that in which the population reached 500,000 in the case of New York, Chicago and Philadelphia, and 250,000 for the remaining five cities. Curve No. 3 was plotted from the data for all years until the population reached 500,000 for New York, Chicago and Philadelphia, and 250,000 for the remaining five cities. Curve No. 1 will represent the population curve which will take into account all the conditions affecting the growth of a big city from its beginning as a city of any size, up to the present time. Curve No. 2 will represent the population curve which takes into account only those conditions affecting the growth of a city after it has become a city of importance. Curve No. 3 will represent the population curve which takes into account only those conditions affecting the growth of a city from its beginning until it becomes a city of importance. The use of Curve No. 3 would enable one to estimate the population of a city which at the present time had less than 500,000 or 250,000 inhabitants. Curve No. 2 would enable one to estimate the future population of a city which at the present time had over 250,000 or 500,000 inhabitants. If the values taken from the extension of Curve No. 3 were approximately the same as those from Curve No. 2, and if the values from either 2 or 3 were approximately the same as those from Curve No. 1, proof would have been established that the law governing the growth of cities of any size was a uniform law throughout their growth and in that case a general formula could be deduced which would represent the growth of any city throughout its life.



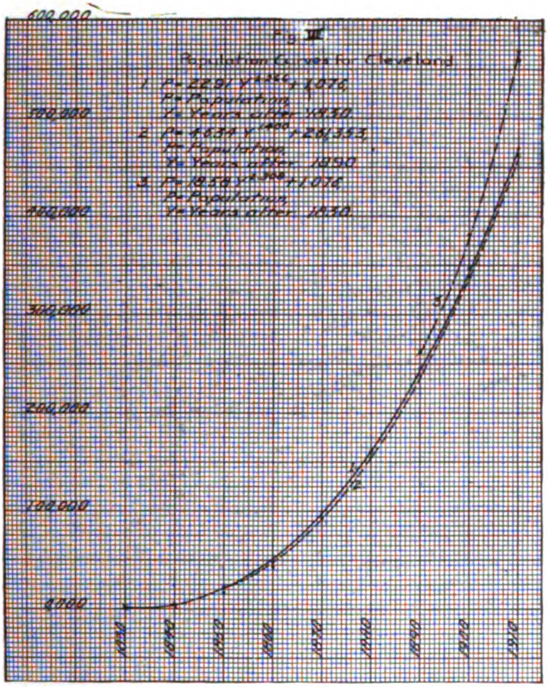
The curves covering the above conditions may be plotted from the following formulae:

New York . . . Curve No. 1, $P = 118\ Y^{2.137} + 49{,}401$
where Y = years after 1790.
Curve No. 2, $P = 101570\ Y^{1.394} + 391{,}114$
where Y = years after 1840.
Curve No. 3, $P = 1362\ Y^{1.316} + 49{,}401$
where Y = years after 1790.
Chicago. . . . . . Curve No. 1, $P = 160.7\ Y^{2.220} + 4{,}470$
where Y = years after 1840.
Curve No. 2, $P = 43.750\ Y^{1.100} + 503{,}185$
where Y = years after 1880.
Curve No. 3, $P = 138.7\ Y^{2.242} + 4.470$
where Y = years after 1840.
Philadelphia . . Curve No. 1, $P = 152.4\ Y^{1.794} + 28{,}522$
where Y = years after 1790
Curve No. 2, $P = 3{,}133\ Y^{1.489} + 565{,}529$
where Y = years after 1860.
Curve No. 3, $P = 691.8\ Y^{1.187} + 28{,}522$
where Y = years after 1790

Baltimore....Curve No. 1, $P = 242.7\ Y^{1.592} + 13,503$
where $Y =$ years after 1790.
Curve No. 2, $P = 3327\ Y^{1.263} + 267,354$
where $Y =$ years after 1870.
Curve No. 3, $P = 523.6\ Y^{1.360} + 13,503$
where $Y =$ years after 1790.
Cleveland ....Curve No. 1, $P = 22.91\ Y^{2.266} + 1,076$
where $Y =$ years after 1830.
Curve No. 2, $P = 4,634\ Y^{1.400} + 261,353$
where $Y =$ years after 1890.
Curve No. 3, $P = 18.58\ Y^{2.308} + 1,076$
where $Y =$ years after 1830.
Pittsburg.....Curve No. 1, $P = 9.55\ Y^{2.269} + 1,565$
where $Y =$ years after 1800.
Curve No. 2, $P = 15,140\ Y^{0.875} + 235,071$
where $Y =$ years after 1880.
Curve No. 3, $P = 12.02\ Y^{2.178} + 1,565$
where $Y =$ years after 1800.
St. Louis.....Curve No. 1, $P = 4,487\ Y^{1.176} + 16,469$
where $Y =$ years after 1840.
Curve No. 2, $P = 1,362\ Y^{1.526} + 310,864$
where $Y =$ years after 1870.
Curve No. 3, $P = 2,576\ Y^{1.359} + 16,469$
where $Y =$ years after 1840.
Boston.......Curve No. 1, $P = 28.05\ Y^{2.053} + 18,320$
where $Y =$ years after 1790.
Curve No. 2, $P = 3,639\ Y^{1.333} + 362,839$
where $Y =$ years after 1880.
Curve No. 3, $P = 99.31\ Y^{1.712} + 18,320$
where $Y =$ years after 1790.

It is obvious that the factors governing the growth of the cities studied are different in each case and no common curve or formula can be deduced which will apply with reasonable accuracy to all. The most peculiar fact which may be noted, however, is that after the population of a city reaches 250,000 or 300,000, the rate of increase becomes much greater and the curve shows a pronounced inclination towards the vertical. This characteristic seems to prevail regardless of the present size of the city, its location, or the time in which it reached the population noted. The following table illustrates the above statements more clearly, the date given being the census year in which the population reached or passed 250,000 or 300,000:

New York	1840
Chicago	1870
Philadelphia	1860



Baltimore	1880
Cleveland	1890
Pittsburg	1880
St. Louis	1870
Boston	1880

Another characteristic which may be noted is that eastern cities show a much slower rate of increase than is the case with the western cities. The curves for Chicago, Cleveland and St. Louis show this uniformity as a group, and the same holds true for the curves for New York, Philadelphia, Boston, Baltimore, Pittsburg.

Among the western cities studied, little effect is shown in the rate of increase due to facilities for transportation by water. The rate of increase for the lake cities, Chicago and Cleveland, does not differ materially from the rate of increase for St. Louis, water transportation on the Mississippi not being considered as comparable with lake shipping. The same characteristic seems to hold true in the eastern cities studied. The rate of increase for Pittsburg being about the

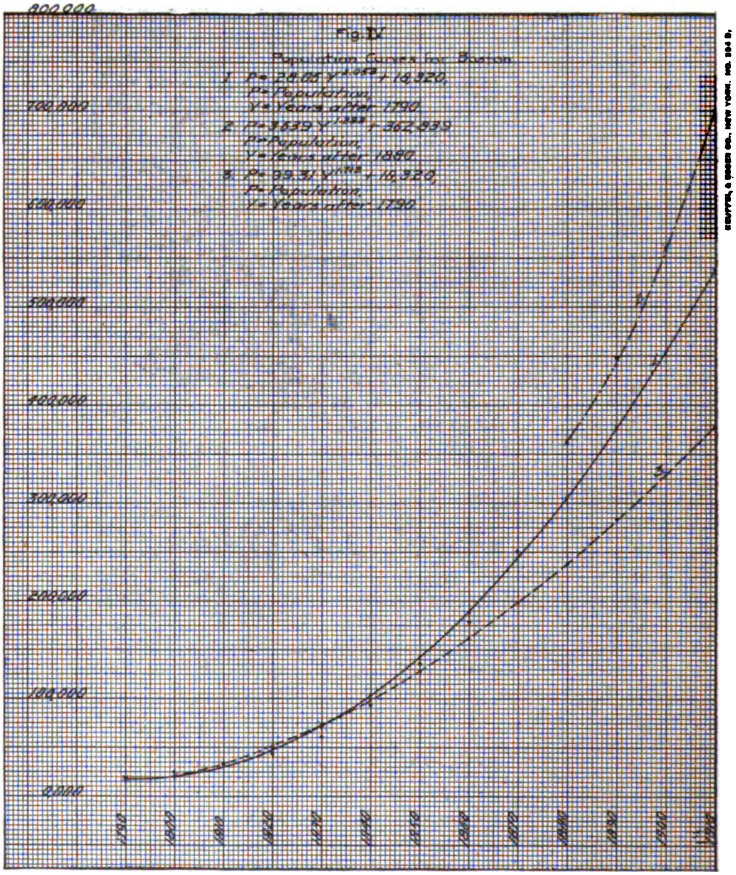


Fig IV

Population Curves for Boston

same as for Boston, Baltimore, and for New York and Philadelphia when the two latter cities were of about the same size as Pittsburg is now.

From the data at hand it seems logical to assume that; when a city reaches a population of about 500,000, the natural resources, tributary, rail and water transportation facilities and opportunities for expansion by annexation, etc., are present in such degree that they have carried the city over what may be termed the critical period prevailing when the population is less than 300,000 and that from this time on the rate of increase will be uniform and more rapid than was the case before the population reached 500,000;

that cities which lie in what may be termed the central or western sections of the country will show a much more pronounced rate of increase at all times than is the case with cities in the eastern or southern sections of the country; that the rate of increase of all cities, regardless of location, transportation facilities and tributary country surrounding, is much less when the population is less than 300,000 than is the case after the population has passed that figure.

During the course of the investigations mentioned at the beginning of this article, the writer made a study of the methods in use at the present time among engineers in estimating future growth of cities and found no reasonable uniformity among them. In a more or less vague way, the prospects for future expansion are dependent entirely upon the judgment of the estimator as to what conditions will prevail after a period of 25 or 50 years has passed. Inasmuch as no man can know what the future holds in store, it seems to the writer that the safest plan is to let the past govern the prospects for the future, provided there are sufficient data covering the past, and prolong the curve to estimate the conditions in the future. This seems to be especially true if the data be separated into two parts and those dealing with the population below 250,000, used for estimates up to 500,000; while the data dealing with population above 250,000 are to be used for all future estimates.

So far as the writer is aware, the Bureau of the Census is the only estimator which governs its estimates of future population entirely upon records of the past. That Bureau uses the straight line formula entirely, stating that their experience shows this to give the more accurate results. While they recommend this formula, they do not officially endorse it. Curves worked out according to the theory of least squares, check fairly closely with the straight line curve mentioned above, though the values from the straight line curve are generally slightly below those submitted by the writer.

THE EVOLUTION OF EXCAVATING MACHINERY

By J. D. Rauch, ex-'95*

Synopsis: A short history of dredges and steam shovels, and the conditions which have caused their rapid development.

Probably one of the most obscure classes of machinery, yet one that has contributed much to the development of the country as well as the conservation of our natural resources, is that employed in the excavation of drainage and irrigation ditches as well as canals and other engineering operations for the development of commerce and industry.

Such machinery may be divided into two general classes: First, that which is mounted on floats or barges for excavation in water; and second, that which is mounted on trucks or platforms for dry excavation.

At the time when our middle west was being settled, and before the advent of the railroads, canals were the only means offered for cheap transportation and many great canal systems were built at considerable cost. The vast amount of excavation required in the construction of these canals was done chiefly by hand labor—and yet this was so short a time ago as to still be clearly within the recollection of persons living today.

Within a few years, however, railroads began to be constructed, with which the canals could not compete as common carriers. It has often been a matter of conjecture to the writer as to what the result might have been had they possessed the efficient excavating machinery then that we have today.

But these canals did more while in operation than to provide avenues of commerce. They served as drains for the adjacent lands, greatly increasing their fertility and value and naturally creating in the minds of men the desire to further expand this phase of reclamation.

As the country became more thickly settled the great areas of wet and overflowed lands in the middle states and especially in Illinois and Indiana attracted attention and means were considered for carrying off the water by artificial channels.

These channels, or ditches we may call them, were first excavated by manual labor. The results obtained in reclaiming the land were sufficient to justify the necessity of some more extensive and efficient means of excavation and efforts were made to construct machinery to do the work.

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* Sec'y-Treas., The American Steel Dredge Co., Fort Wayne, Ind.

About the year 1880 a crude but fairly successful ditching dredge was built in northeastern Illinois. This machine was not only capable of doing the work better, but so much cheaper than any former methods that it immediately commanded attention. It was the nucleus of what is now generally known as the dipper dredge—a type which, with the many improvements made since its advent, is recognized as the most efficient and economical type and is employed almost exclusively today in drainage work, as well as in the canal construction and deepening of our rivers and harbors. The dipper dredge is essentially an American machine. It has shown its superiority over other types in many instances, the most important example being probably the construction of the Panama Canal, which was successfully accomplished after several futile attempts with foreign types.

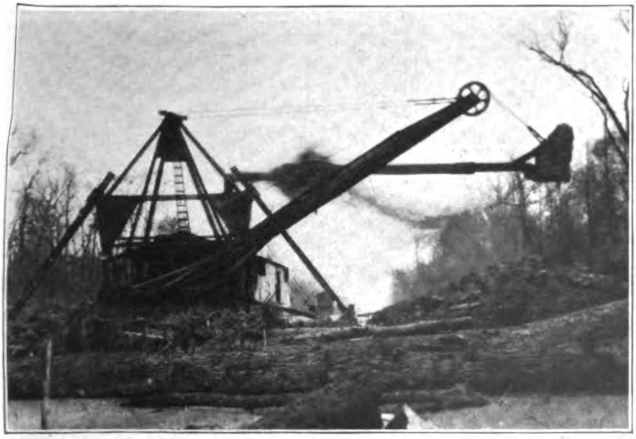

Fig. 1. Dipper Dredge.

Originally dredges were constructed with wooden booms and superstructure and mounted on wooden barges. The modern dredge is built of steel throughout including the barge, as shown in the accompanying illustration, and is capable of coping with the most heavy and difficult work.

With the vast areas of waste lands yet to be reclaimed, and the untold canals and harbors for commerce yet to be conceived in this and other countries, this class of machinery offers a most promising field for the mechanical and perhaps the electrical engineer; and for the civil engineer in the planning and maintenance of the work.

We now come to the other, but no less important, branch known as dry excavation, which embraces even a wider and more varied field, such as canals for carrying and distributing water in the irrigation of arid regions, the construction of modern roads, which is just now opening up in almost inconceivable proportions in every section, and on down to subway and tunnel excavation, as well as a myriad of other but equally important and economic operations.

For such work the steam shovel was evolved and has been brought to a state of efficiency that is astounding.

One of the latest and most universal types is what is known as the revolving shovel, such as is shown in the accompanying illustration (Fig. 2.) It is mounted on a swiveling truck so as to revolve in a complete circle, and is capable of traveling from point to point under its own power.

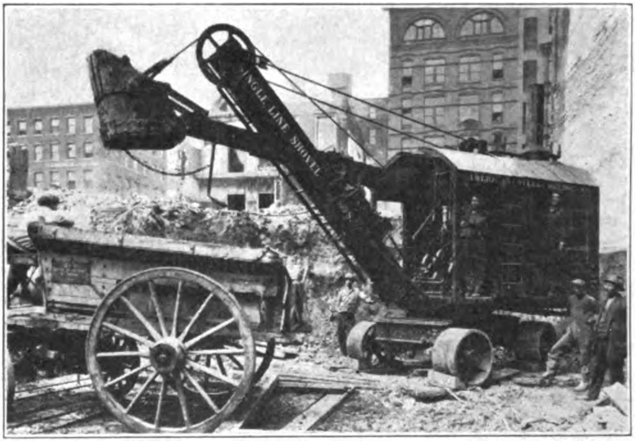

Fig. 2. Revolving Shovel.

For years practically all the iron ore from the ranges of the Northwest has not only been mined and loaded into cars by steam shovels, but the beds of ore have been previously stripped of the overburden of soil by the same machines. This has been a most important factor in the development of the steel industry, and its effect on the cost as well as the increased production of iron and steel can hardly be computed.

The field is still open for unlimited improvements and each year brings forth new opportunities for expanding the range of usefulness of machinery of this class, which should not be overlooked by the engineer.

PRINCIPLES OF DRAINAGE DISTRICT ASSESSMENTS

By R. G. FLAUGHER, '12*

Synopsis: The engineer in charge of drainage projects meets many problems in his contact with owners of farming land and by no means the last of these is the question of apportioning assessments according to the value which an individual will receive, and to the location of his ground. In this article Mr. Flaugher summarizes methods of assessments which have been used successfully.

Perhaps in few fields of his endeavor is the engineer required to exercise more tact and perseverance than in that of drainage engineering. The great variety of conditions in the topography of the drainage area, the varying degrees of soil fertility, the relative distances of certain tracts from the main ditch and the completeness or incompleteness of the drainage, combine to make the task of handling a drainage district far from a simple one. Furthermore, because of friction between the interested parties concerning matters connected with the drainage work, the engineer is often caused much embarrassment.

The only course to follow is that of strict adherence to engineering principles and close observance of the state drainage laws, as well as the use of common sense, tact, and neutrality.

It is impossible to lay down a set method to follow in the levying of assessments or the awarding of damages. There are, however, ten fundamental principles which apply in the making up of an assessment roll for a district.

1. A land-owner is by virtue of ownership entitled to any drainage that his land may possess. He may construct any system of drains that he deems necessary so long as it is done within the limits of his land, provided the outlet is in a natural watercourse through his own holdings.

2. If the natural outlet for the territory surrounding him is through his own property he cannot be assessed for any part of a public drainage system unless it is evident that he is actually benefited by the drainage of the adjoining property. Where the natural slope of the surrounding land is such that without a drainage system he would be compelled to take care of the water coming from above his land, then the public drainage system will benefit him to the extent of the injury suffered because of the wet condition of the surrounding land.

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* Cayuga, Ind.

3. If no such condition exists and no other benefit is apparent the assessment should be omitted. On the other hand, he is entitled to recompense for the right of way necessary for the public drainage ditch through his land. Where the owner refuses permission for the construction of the drainage ditch through his holdings, the authorities may condemn such land for public purposes. The right of passage cannot be withheld. The owner is awarded such damages as is necessary to cover injuries sustained, by a jury appointed for such purposes.

4. Other things being equal, the greater the amount of water removed from a tract of land, the greater the amount of assessment levied. An area that is wet and useless for agricultural purposes should be assessed proportionately higher if reclaimed by the construction of an adequate drainage system than other land lying in the same district which has better natural drainage.

5. The land occupied by the right of way should not be assessed for benefits, since it is evident that owner will never receive any direct returns in the future. The number of acres used for this purpose on each piece of land should be subtracted from the total area and not be considered on the assessment sheet. Although, theoretically this is correct, the amount involved except in expensive improvements and large areas owned by the same individual is negligible. This point is nearly always disregarded.

6. Where, within the limits of a district, the soils because of their type or structure are variable in fertility, those most fertile should be assessed proportionately higher than those possessing a lesser degree of fertility.

Sometimes it occurs that one tract is capable of producing higher priced crops, while others are only available for the production of ordinary crops. This condition has often obtained in the Kankakee regions of northwestern Indiana and northeastern Illinois, where the proximity to the Chicago markets renders the various types of loam and sandy loam soils very valuable for the production of market garden crops.

7. If a public drain incidentally passes through a tract of land for the purpose of giving more perfect drainage privileges to the surrounding area, and in so doing affords direct drainage to the particular tract as well as decreases the expenditure necessary to complete its drainage, this land should be assessed proportionately higher than the land adjoining for the reason that private drainage has been accomplished

at public expense. It is, however, necessary for the proper authorities of the drainage district to prove their point in a case of this kind. Just such technical questions as these are constantly arising. They afford no end of worry to the engineer and no end of remuneration for the members of the legal profession.

8. The nearer a tract of land lies to the natural outlet the smaller the assessment should be, provided the drainage advantages are the same. The basis of this principle lies in the fact that the land more distant from the outlet has been brought within the reach of drainage facilities. The land contiguous to the drainage ditch possessed such facilities previous to the construction of the main outlet.

9. If complete drainage is not furnished to the lands of an entire tract, those which receive only partial drainage should be assessed in proportion to the benefits received.

10. Outlet privileges should be assessed in proportion to the distances from the drainage ditch.

In the construction of any public artificial drainage system, it is seldom possible to avoid damages to property in some manner or other. Although the chief cause for damages is the use of land necessary for right of way, there are other claims for which damages are allowed.

The cutting up of fields into irregular and small tracts causes extra time and labor for the cultivation and harvesting of crops; the proximity of the ditch to certain structures and the destruction of the water loving timber, are sources for the awarding of damages. Again the destruction of growing crops and the cost of construction of additional fences demand remuneration.

Next to the damage to land for right of way purposes, the damages to highway and railroad properties are most important. Traffic on highways is often stopped or averted during the construction of the ditch itself or of the bridges incident thereto. The excavated material must be removed, causing some expense.

Railroads are affected to a greater degree than highways. Traffic is entirely dependent upon a continuous line of steel and a firm and undisturbed roadbed. It is usually extremely costly or impractical to provide a sidetrack for temporary purposes. Detouring is not always possible. Of course damages are sometimes allowed, but seldom commensurate to the expenses of delay and inconvenience involved. Often a new bridge must provide for the outlet, or an old structure be replaced by a new one because of additional water carried. The railroad pays for the new bridge, of course. The railroad also pays an additional assessment for other benefits received, which, in justice, let it be said, are often many. The value of a well drained roadbed is very great. Furthermore, the welfare of any railroad is directly dependent upon the agricultural resources of territory through which it passes.

The management of a drainage district involves no little responsibility, and the drainage engineer must possess special training. He must not let enthusiasm for his work carry him beyond the bounds of engineering technique. He must be a wise and honest counsellor, he must be well versed in the knowledge of civil engineering, agriculture, drainage law and human nature.

SOME PERSONAL IMPRESSIONS OF AVIATION.

By J. C. TURPIN, '08*

Synopsis: Mr. Turpin, who was one of the first pupils of the Wright Brothers in the study of aviation, and whom we all remember as being one of the famous members of the original Wright exhibition team, tells in a most interesting way of some of his experiences while engaged in this very strenuous sport. It might be well to add that Mr. Turpin and Mr. Walter Brookins are the only members of the original team that are alive today, both of them having retired from the game several years ago.

So much has already been written in regard to aviation that the following article will deal entirely with my personal affiliations in the flying game. My entering into this, one of the most alluring of sports, was during the early Spring of 1910, when I was approached by Mr. Orville Wright who gave me the opportunity of becoming one of seven of the initial members of the Wright exhibition team. My early training began in Dayton, Ohio, under the personal tutelage of Mr. Orville Wright.

To the uninitiated, learning to fly an aeroplane must seem like a very easy task, but I can assure those who have this opinion that this is not at all true. All training of men, then as well as now, is done in a machine in the air, under the direction of a proficient instructor. The required time for a man learning to fly an aeroplane usually covers a period of about four weeks, as the training of new pilots can only be conducted under the most favorable weather conditions, by which I mean that air conditions must be absolutely calm. These conditions are most prevalent in the early morning and the late afternoon.

In driving an aeroplane four directions must be considered, the two directions fore and aft, and also the side balance of the machine. The side-balance is controlled by what is called warping the planes. If the right side of the machine is low, the wings on that side of the machine are warped or lowered. These lowered planes meeting the onrush of air, offer more resistance to it, and are immediately raised. In like manner, if the left side of the machine is low, the left wings are warped, more surface is exposed to the air and this side of the machine is therefore raised. The elevation and inclination of the plane is controlled by a rear elevating rudder. In the first types of planes built by the Wrights the motor was controlled by a foot lever, being fully accelerated at the time of starting, and running under full power during the entire time of flight, only being throttled down for making landings.

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* The American Cotton Co., Boston, Mass.

The landing on an aeroplane is by far the most difficult operation in flying, for it is only at this time in coming close to the ground that the operator realizes the extreme speed of the machine. When one considers that a machine of extremely light construction and weighing around 1200 lbs. with the operator, is compelled to land at the rate of from fifty to sixty miles per hour on sometimes very rough ground, one can easily understand the skill it requires to avoid demolishing the planes.

My first lesson and also my first ride in an aeroplane was to me an extremely disagreeable experience. The nearest approach to a comparison is that of riding in an automobile at the rate of fifty or sixty miles and hour over very rough roads. The statements of those of my passengers whom I took up in later days that they had enjoyed the experience immensely, I always took "with a grain of salt," as I knew very well that while they were glad to have had the experience, they were more glad to again be able to place their feet on solid ground. I never experiencd in all my flying career the sensation of dizziness due to height. The reason for this I cannot explain, for I, like others when in a very tall building, looking down toward the ground, have an extremely giddy sensation.

During my three years in active flying I made in all about 2500 flights, flying in almost every city in this country and during this entire time I only met with one accident. Before a flight I absolutely assured myself that the machine was in as perfect condition as was possible, that the motor was delivering maximum power, etc. In the early days of flying the greatest source of trouble was the motor. Under the most favorable circumstances the motors only developed thirty-five horse power, and their life in the air was about twenty hours. I have many times had the experience while in the air of having an exhaust valve drop through the head of a piston and come out through the bottom of the crank case. In order to guard against such troubles it was always my policy to fly as high as possible, for in height there was safety. To explain the foregoing statement I will say that the gliding angles of these planes were about six to one, in other words, for one foot vertical drop of plane, you could glide in a horizontal direction six feet. By flying at a fairly good height of say approximately 2000 feet, this would mean that in case your motor stopped, if landing conditions were not favorable directly underneath, you could glide a distance of over a mile, and in this radius you could easily pick out favorable landing conditions.

One experience above all others will always remain vividly impressed upon my mind. This occurred in California in a flight from Venice to Long Beach, a distance across country of about twenty miles. Both towns are located on the coast. I had completed my exhibition in the former place and was flying my planes to Long Beach in order to be shipped East. The day was exceedingly foggy and the clouds hung at a distance of not over 1000 feet above the earth. As I knew the course well between these two points, I decided to mount above the clouds in order to strike better atmospheric conditions. My readers will understand that when I make the statement of flying above the clouds that under these conditions the earth is absolutely blotted from view. After flying for what I considered to be the proper time to cover the distance between these two places, I began to make my descent, and upon coming through the cloud banks I found that instead of being near Long Beach the wind had carried me over ten miles out to sea. Under these conditions I was absolutely at the mercy of my motor for if it had stopped at that time, there would have been nothing for me to do but make a landing in the water, and this would have been very serious as there is very little traffic along these shores. However in this case, as in many others, my motor power remained faithful to the last and I was able to reach shore without any further qualms.

The aeroplane of today has been refined in many details over the machines of five years past, as to workmanship, construction and to far superior motors. But as to the handling of the plane and as to the safety of the operator exclusive of the above features, no advancements have been made. This step however is bound to see the light of day within the near future, and it is my opinion that in the next twenty-five years, aviation will have advanced to a point where there will be comparative safety in the operation of aeroplanes.

SOME PHASES OF RAILWAY TRAFFIC STUDY WORK

By L. E. Stibbe, '15*

Synopsis: The method of taking and working up the data and the interpretation of the results of a street railway traffic study is described.

The profits of an electric road depend primarily on the effectiveness of its schedule. Especially is this true in the case of city lines where the income depends almost exclusively on passenger traffic, when it is necessary that the company conform in a sense to the movements of the people. The aim of the company should be to have only a sufficient carrying capacity at the proper place and at the proper time. The number of passengers carried per car mile should be a maximum, and this results directly from a proper schedule, which in turn can only be arranged with a thorough knowledge of the movement of the waves of people, their magnitude, and the time when such waves occur. More than this, the operation of a street railway system is a public enterprise, and due to this fact too, it behooves a company to strive to give complete and efficient service for other reasons than for personal financial gain. Operation in congested, or even frequently congested city districts, is subject to complications, remedies for which become almost imperative. It is acknowledged that for the arrangement and application of a satisfactory schedule, knowledge of details regarding the service and traffic conditions must be available, and this can best be obtained through observations and data taken in a thorough traffic study.

Traffice studies, therefore, should be conducted with a view toward determining if the public is realizing the best possible service, under the most profitable operation from the company's standpoint. The data should be sufficient to make it truly representative of all or many conditions of operation, and any results influenced by some unusual occurrence should be recognized and noted. Observations should not only be made throughout the entire day, but the study should extend over a period of time sufficient to include possible changes in business and weather conditions.

Different methods of obtaining data may be used. Observers may be stationed at some point of maximum loads along the route to record the loads on all cars that pass.

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* The General Electric Co., Schenectady, N. Y.

This method can be used only to find approximately how the loads occur and how they are being handled, and only on the more simple city lines. A more complete method is to ride on all the cars or on a representative car the entire length of its route, recording the changes in load at each stop, the character of the traffic, and all the conditions obtaining. Fig. No. 1 is a fac-simile of a data sheet with data taken by the latter method, which, as are also the figures following, is taken from the results of an extensive traffic study on one of the city lines of the LaFayette (Indiana) Street Railway system.

Referring now to Fig. No. 1, at the top is recorded some general data. In the ruled sections below is found the special data, which includes for one trip, "out" and "in," the number of people who get on or off at each stop, their classification, the time consumed at each stop,—taken with a stop watch,—the number standing in the car, and the total number of passengers being carried. The latter item is readily calculated after the trip is made. The number standing is taken so that if a few passengers usually stand by preference, the virtual capacity of the car may be taken, when considering overloads, as a certain percentage above its seating capacity. In the parenthesis are recorded the register readings at the end of the trip each way. These values, due to some children and so called deadheads riding, is usually smaller than the total number of people carried for the trip, and may be used to calculate a percentage of paying passengers.

The calculated values tabulated in the "Total On" column are the actual loads at points along the route, and taken collectively they show readily how the load on the car actually varied. The method in most common use for representing this variation is by the use of curves plotted with these values of load as ordinates, corresponding to points along the route as abscissae. Fig. No. 2 shows a so-called load-curve for one trip "out" and "in." Besides showing the general variation in load over the route, it is drawn to show the loads to be constant between stops and the change in load at each stop. The comfortable load line is drawn at the value of the virtual capacity of the car as calculated by the method explained above.

It is obvious that values for these load curves must be average values. If it is seen that the waves of traffic occur in a relatively similar way on certain days of the week, MARCH 6, 1915.

CAR NO. 226 OBSERVER L. E. S. TEMP.—30° F.
SHEET NO. 315 WEATHER—CLOUDY

START IN: 8:02 P. M. START OUT: 8.17 P. M.

(18) STOPS	OUT											(16) STOPS	IN										
	On	Men	Women	Children	Off	Men	Women	Children	Time	Standing	Total on		On	Men	Women	Children	Off	Men	Women	Children	Time	Standing	Total on
4—Main												4—Main											
3—Main												4—Col.											
3—Col.	2	1		1					6		2	3—Col.					5	1	2	2	9		0
4—Col.	2		1	1					5		4	3—Main											
4—Main	5	2	2	1					9		9	4—Main					5	2	3		8		5
5																	1	1			1		10
6	4	1	2	1					10		13												
Alley	1		1						5		14						3	2	1		6		11
7																							
8	1	1							$^{1}/_{40}$		15						3	1	2		3		14
9—Main	5	2	2	1					22		20						3	1	2		1		17
Columbia																	1		1				20
South																							
Wab.R.R.	2	1	1						5		22												
N. Stop.																							
S. Stop																							
Hitt																							
State																							
Crossing																					$^{2}/_{1}$		
Elliott					1		1		1		21												
9—Kossuth					5	2	3		9		16		13	4	9						21		21
10					3	1	1	1	3		13												
11					4	1	2	1	7		9		1	1									8
State																							
14																							
15					2		1	1	3		7												
16													2	2							5		7
18					1	1					6												
19																							
20					2	2			1		4												
21																							
22					2	1		1	2		2												
Main																							
24																							
Park Ave.													4	1	1	2					6		5
Loop					2		1	1	7		0		1		1								1

FIG. 1.

then data taken on these days should be grouped and averaged together. Again, it is reasonable to suppose that the traffic will vary according to a rule at the same periods of the days in any one group. Therefore, load values should also be averaged from data taken at the same hours. Consequently, a set of hourly load-curves should consist of one for each period of time embracing the time of the trip and there should be as many such sets as there are groups of days on which the traffic is held to be similar.

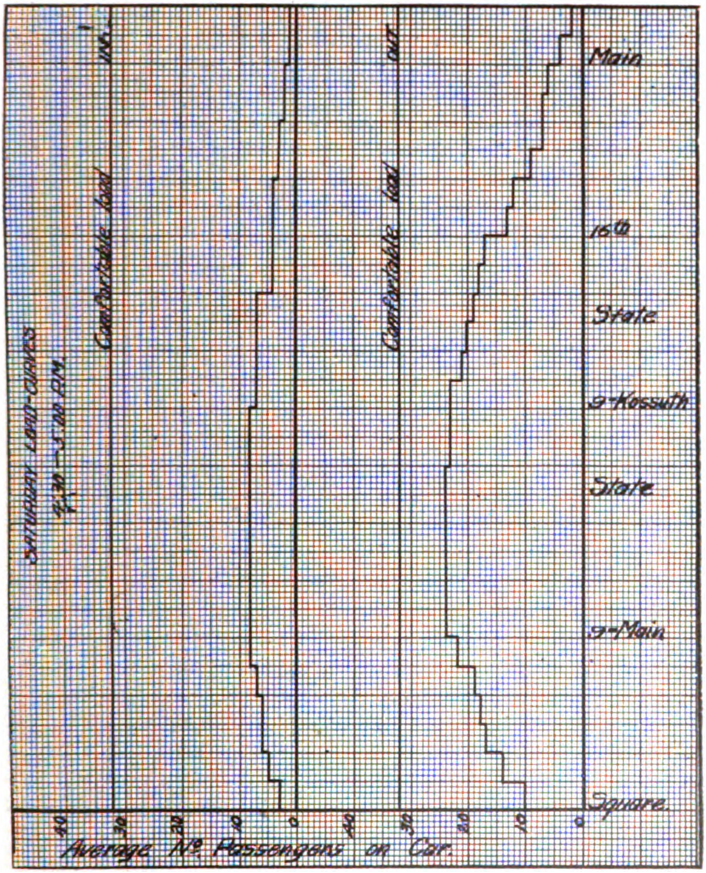

Fig. 2.

If a general average load-curve is desired representing all the days on which observations were made, values for it may be found by adding the loads realized at each point on the route for all the trips made and dividing by the number of trips. Or if values for the sets of hourly load curves have been found, these may be added for each point on the route, and the sum divided by the number of sets of curves being used.

The type of curves spoken of thus far are very good to depict conditions of traffic within the limits of the route and for any period of the day. However, besides knowing the variation in load within the time of the run or trip, and for a succession of consecutive trips, it is often desirable and interesting to know the variation of the maximum load with time, extending over a period of a whole day. To this end so-called all-day load-curves for any group of days may be drawn as shown in Fig. No. 3. These curves show the variations in the total number of people carried per trip. But similarly for a group of days they must represent average values and as such may be transferred from the highest point on each of the hourly load-curves already drawn. In a word, these curves show the total number of people riding "in" and "out" at all times of the day.

The first indication of an incompetent schedule and poor service is the existence of frequent and successive over-loads. From the company's standpoint unsatisfactory service is more quickly made evident by consistent zero-loads. The necessity for improvement as well as its possibility lies in the recurrence of these abnormal loads. The waves of heavy traffic that a schedule must sometimes be corrected to relieve are shown most readily on the all-day load-curves. Referring again to Fig. No. 3, they are seen to be of but short duration and may be accounted for in this case as follows: Workmen and clerks go "in" from 6:30 to 8:30 in the morning; clerks and business men go home at 12:00 M.; and some return about 1:00 P. M.; shoppers and clerks return home from 5:00 to 6:00 P. M., thus causing the only average over-load for the group of days that this curve represents; theatre goers and others go "in" about 7:30 P. M., and larger loads of the same go "out" after nine o'clock.

Cars are generally chosen to best suit the purposes which they will serve. They and their equipment are designed to give the most satisfactory service in their sphere of operation. For instance, the power and braking equipment on a car used in a congested business district must be such as to accelerate and decelerate the car quickly. More than this, the cars themselves may be designed to enable the passengers to move more advantageously, thus reducing the time of stop to a minimum, which in turn reduces the time necessary to complete a trip. To compare in this respect the use of cars of different designs, the data recorded on the time of stops is utilized. Thus it may be found that a single vestibuled Monitor type car may be much less efficient in handling passengers than the more recent P. A. Y. E. or Near Side cars or those with a center

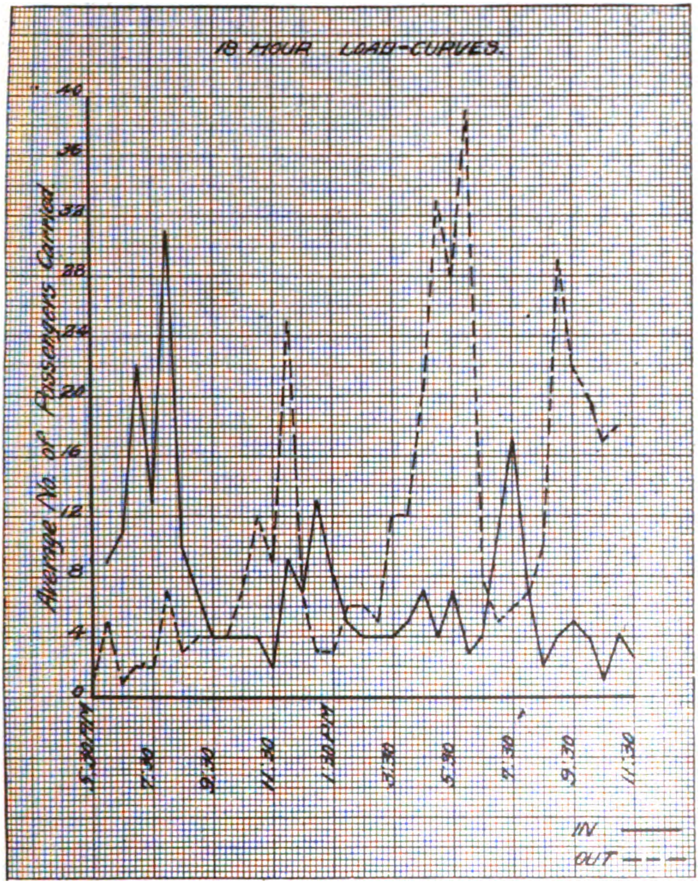

Fig. 3.

entrance or the double vestibuled type. To represent effectively the results on the time of stops there should be figured an average value per passenger of time in seconds required to board or alight for separate cases when different numbers of passengers get on or oft.

The foregoing are the more important results and facts disclosed. Other things of more or less detail may be dwelt upon such as car heating and ventilation, courtesy of employees, convenience in placing cars, how the qualities of traffic affect the service, etc., suggestions for which develop out of the particular conditions and circumstances in hand.

The study in which the writer was interested, and from which the foregoing plates were taken, was made for ten complete days. The average maximum load "out" and "in" respectively during the whole period was only 40% and 25% of the comfortable load, and at no time was it seen advisable to lighten the schedule. The percentage of paying passengers for six of the ten days was 88% to 94% of the total number carried. Such statistics are perhaps not uncommon. Problems that confront officials of any public utility company are seldom comprehended by the complaining public which does not even realize that there is a limit to the distance a patron can profitably be carried for the customary five-cent-fare. Moreover, with the coming of the jitney in very recent years, electric railways have met a not only formidable but unfair competitor, and legislation will be gladly welcomed that puts these two operating companies on a more equal basis, sharing alike the expense and responsibility, as well as profits. Too often we find those who look defiantly at a needful corporation as if at the hand of an oppressor, and a more congenial and cooperative spirit can only be obtained through a more generally educated public.

IS THE ANSWER YES OR NO?

By F. F. CHANDLER, '99*

Synopsis: Mr. Chandler in this paper condemns the Public Service Corporations for not performing the service to the Public that their name implies and that their franchises require. As an example of a successful municipal owned utility, the small isolated power plants of Germany are cited, and the reason for their successful operation explained. It is claimed that Public Service Corporations in this country are in the hands of financiers, who manipulate them so as to yield large dividends to themselves, and the Public has to pay the bill. Prediction is made that this country is coming to municipal ownership.

This is not a love story or a novel with a detective sleuth plot, although it must be admitted that the caption has an air of mystery about it. But as the subject, itself, is more or less mysterious, it is felt that the caption is as good as any which could be selected. Like a great many citizens who live in any city large enough to boast of having Public Service Utilities, the writer has a suspicion that these organizations of capital are not really Public Utilities at all, but are in reality footballs in the scrimmage for wealth. What, in truth, is to be dealt with in this paper is therefore, "Shall we have municipal ownership?" Is the answer yes or no?

In any game of athletics the real way to become familiar with the feints of the adversary is to play the game against him. Feint is a good word. The dictionary says that it means pretense or mock attack, and mock attack means to pretend to do something which is not intended to be done.

Public Service Corporation is a phrase pleasing to hear. It is a good selection of words meant to carry a high toned thought, but let us see what the word "serve" means. "Serve" means to be subordinate or subservient to, to aid by good offices, to minister to the wants or well being of. We must, all of us, admit immediately that Public Service Corporations are not subordinate or subservient to the people. They do minister to the wants or well being of the people, but not in the big wholesome way that the word service implies. In short, they do not serve the public as well as they could and should do, and they therefore pretend to do something which they do not accomplish. This is a rather plain way of saying it, but just play the game against these adversaries for a while and you will find out that these statements are true.

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The writer does not mean that the people would be better off without these Public Service Corporations, because that would not be true. The fact is certainly appreciated that good light, good heat, good water, good transportation, etc., are all conveniences which every one is better off for having. It is found, however, that when our franchises are given up for these benefits, we still have to fight to get the benefits, and generally speaking, we have to pay more for them when we do get them than the same service is worth. It is felt that if the public only knew what the writer has learned from long contact with public utilities, they would vote for municipal ownership at the first opportunity.

Because a study of whether or not we should have municipal ownership is an interesting one and one which the readers of the Purdue Engineering Review, as engineers, should delight in, the writer wishes to point out some general facts in connection with the problem. It can be said of municipal ownership of Public Utilities that it has no reason to exist unless the people can themselves own and operate the utilities at a less cost than the price which they are compelled to pay when the utilities are privately owned. The problem therefore becomes this: Can utilities be operated more cheaply by the people? If they can, then the people will want municipal ownership. The writer believes that the answer is "yes" and that privately owned utilities, or a great many of them at least, could serve the public and more cheaply than they do. They will not do so, however, unless they are forced to it.

There are a great many items which have to be carefully weighed in this consideration. No particular problem will be taken up and analyzed carefully for you, but there are some pertinent facts, made by precedents which stand out strongly in favor of letting the people serve themselves.

Electricity, for instance, costs the people of Germany one-half of what it costs in this country. In Germany, this electricity is made with coal which costs four or five times what coal costs in this country and coal is next to the largest item in the cost of production. Labor is the item which comes next to coal. Labor is cheaper in Germany than in the United States but not enough cheaper to account for this great difference in the cost to the consumer.

There is a large loss in the transmission and transformation of electric current. It is surprising to know that such losses between the switch board and the customers' meters vary from 25% to 40%. In the great progressive metropolis of New York it is stated that this loss is 42%. This loss of current in this country is partially accounted for by the custom of building one large generating station and the consequent long transmission lines. Abroad, the generating stations are smaller and are larger in number. The building of these at logical distribution centers cuts down the transmission loss. Railroads find this same difficulty in handling cars in one large terminal. The cost per car is larger than if the terminals are smaller and more advantageously situated. Central station managers say that if the insurance companies in the United States would let them string their lines as they are permitted to string them in Germany, the line investment would drop. It is argued that if the lines in Germany are strung so cheaply and in a way so that the fire hazard is increased (as is claimed here) then the line losses in Germany would be greater than they are here. The comparative cost of current there is lower so that the argument does not "hold water."

In this country some of the board of underwriters have been guilty of conniving with central station interests and have passed rules and regulations which have favored Central Stations. These rules have been against the interest of isolated plants. Private plants to some degree carry out the economical divisional idea of generating stations which have proved economical in Europe. As the overhead charges of conducting central station business in this country is about two and one-half times the cost of producing the current, this, then, becomes the first place to criticise closely.

Even those items of overhead expense in Germany such as taxes, interest, insurance, salaries, etc., are no smaller in per cent than they are here. If this is true, then the present rate theories in this country are harmful as well as beneficial to the interests which use them.

While a large share of the overhead expense is made up of interest charges on watered stocks and bonds, yet there is also incorporated in the overhead expense a large item for advertising and for salaries of the solicitors who try to induce owners of isolated plants to shut them down. It costs money to do this and even if the plant is shut down it is often done at a rate so low that the price will not permit the rate to carry any proportion of the overhead expense whatever. A member of the Indiana Public Service Commission has admitted that such rates do exist. The result of this method of dealing loads upon the central station with more equipment, which costs money and which also calls for further watering of stock, puts the burden on the small consumer.

The above facts, which show that current is sold cheaper abroad than it is sold here, may leave you wondering where the real trouble lies. Abroad, the current is produced in a number of stations instead of one; the production costs less in spite of the high fuel cost; the line losses are less; the interest charge is less. Perhaps you do not know that in plants as small as 35 K. W. the coal needed amounts only to about one and one-half pounds per K. W. hour.

Look up what it costs here. In this country, central station engineers have admitted that they can not hope to compete with an isolated plant which has use for all its exhaust steam. Furthermore, exhaust steam will produce a ton of ice in 24 hours for every three engine horse power produced. Ice has been produced as a by-product in Central stations for 29c a ton. Roughly speaking, if central stations should go into the ice business, then privately owned ice plants would have no cause to exist and the price of ice would drop to 8 or 10 cents per hundred pounds including the delivery. What do you pay for ice?

Of course, this would mean a fight from the ice man, but you, as engineers, should interest yourselves in these things. You, as citizens, should interest yourselves in the juggling of securities as is carried on by the central stations. It is nothing short of criminal. Some day the people are going to settle this condition correctly.

The writer has no intention of fighting against privately owned utilities when they are properly conducted. But the Merchants Heat & Light Co., of Indianapolis, for example, started with about $275,000 in stock. They did not build much of a plant but used exhaust steam to good advantage. They grew into prominence on that account, attracting the attention of capitalists. Then came the usual issuing of preferred stock and bonds, which after all is only another way of borrowing money which a bank would not lend. Interest has been paid right along and this company now values itself at about $6,000,000. An interesting chapter in the career of this utility shows that in one transfer a very few men netted nearly $700,000. Its president is stated to have received $400,000 of this amount. His profit alone was about 150% of the original investment. The Indianapolis Water Company starting out with half a million dollars, has paid out dividends of $6,000,000 and has $8,000,000 left. The newspapers show these conditions to exist all over the country.

A good many cities now have most successful municipally owned plants. Anderson and Richmond in Indiana, Detroit and Cleveland have their own electric light plants, St. Louis and many other cities own their water works, and it would pay one to investigate their rates and earnings.

It is true that many places have shown failures but the cause has always been politics. Is there any less sense in having municipally owned water, light or ice plants or incinerators than there is in having municipally owned streets, sewers and fire protection? If you as engineers will look into the advantage which will come from the combination of plants, the result will be surprising. It is in this manner that the German industrial engineers gain prominence. There, they feel that if they take care of the pfennigs, the marks will take care of themselves, while in this country the financiers will take care of the millions if the "easy marks" will let them alone. The writer is not a socialist but he thinks he has a keen sense of justice.

In conclusion, the absolute prediction is made that we as a country are coming to municipal ownership. We are going to furnish ourselves with water, light, gas, ice and garbage and rubbish disposal and we are going to do it better and cheaper than it is now done. Are you as engineers preparing yourselves for it? If not, you are missing a big opportunity.

LOSS OF HEAD IN PIPES, BENDS, VALVES AND OTHER FITTINGS

By W. E. Stanley*

Synopsis: This article gives the results of an extensive series of experiments conducted in the Hydraulic Laboratory of Purdue University for the purpose of determining the friction losses in bends of various radii, and in valves of several types and at different openings. The apparatus and the method of conducting the tests is described in detail.

The flow of water in pipes is something with which almost every person is more or less acquainted, yet this very common action brings into existence many problems which have attracted the attention and taxed the abilities of some of the best hydraulic engineers and hydraulicians in the past.

One of the important questions in this connection is that of the quantity of energy necessary to overcome the frictional and other resistances to the flow in a pipe line. Many experiments have been conducted, both in the laboratory and in the field, upon pipes varying in diameter from 1-10 inch to 90 inches in the endeavor to establish the relation between the velocity of flow and the loss of head for that velocity. A large amount of data have become available from these experiments for the use of the engineer, from which he may estimate, with some degree of accuracy, the losses which will occur in the straight portions of a pipe line; but, as yet, data from which an estimate may be made of the losses due to the bends, valves and many other standard and special fittings to be found in any pipe line are extremely limited in both quantity and quality.

It is the object of this article to describe and present a few of the general results of an extensive series of experiments conducted from April to June, 1915, in the Hydraulic Laboratory of Purdue University, primarily to study the effects of bends of various radii, valves of several types and at different openings, and several standard and special pipe fittings. The experimental work was performed by the writer as a part of his graduate thesis and by Mr. I. Mazur, '15, who used the part pertaining to bends as an under-graduate thesis. All experiments were made on 1-inch pipe and fittings.

The pipe used was ordinary commercial black wrought-iron or steel pipe having an average internal diameter of 1.0306 inches, as determined from measurements by a vernier caliper at each end of all pieces used. The pipe line, as set up for testing, consisted of three experimental sections. The first section contained a bend and two tangents of straight pipe; the second section was 40 feet of straight pipe; the third section contained a valve and two lengths of straight pipe.

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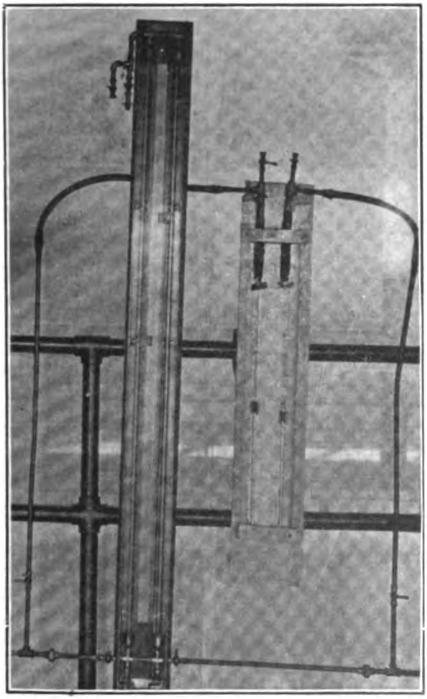


Fig. 1.

The loss of head through each section of the pipe line was obtained by either a water differential gauge or a mercury differential gauge (Fig. 1) connected by a ¼-inch wrought iron pipe to specialize piezometer rings at each end of the section. Losses of head for low velocities were determined by the water gauges while those for the higher velocities were determined by the mercury gauges. In a few cases, pressure gauges were used when the losses were beyond the range of the mercury gauges.

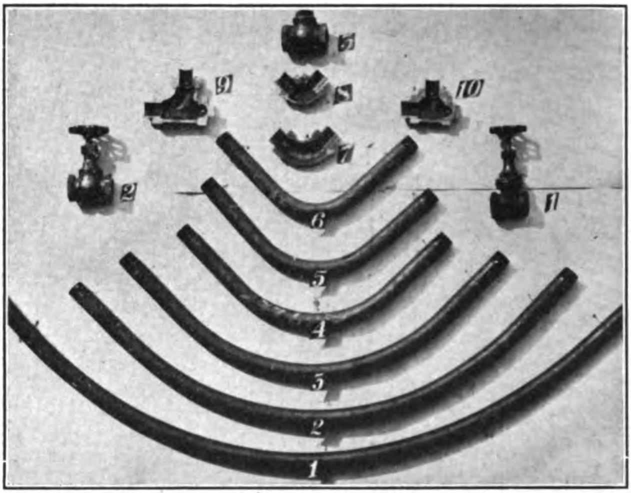


Fig. 2.

Tests were conducted on the bends, valves, and fittings shown in Fig. 2. Bends Nos. 1 to 6, inclusive, were made by bending to the proper radius lengths of pipe similar in character to the straight pipes. Bends Nos. 7 and 8, respectively, were standard "long turn" and "short turn" cast-iron 90° elbows. No. 9 was a standard cast-iron "long sweep special" tee, and No. 10 was an ordinary standard cast-iron tee. The valves were standard brass valves, No. 1 being a gate valve, No. 2 a globe valve, and No. 3 a check valve.

In conducting the experiments, the method used was such that simultaneous readings were taken over all three experimental sections, the gauges being located so that one observer could take care of the bend and the 40 feet of straight pipe sections while the second observer took care of the valve section and the weighing of the water used.

Twenty-five to thirty runs of three to ten minutes duration were made on each bend and for each valve setting, with velocities from 1 to 13 feet per second. After completing the experiments on the bends, valves and other fittings, the pieces of pipe forming the tangents in the bend and valve sections and the 40 feet of straight pipe section were all connected together making a straight length of 80.09 feet for which length a series of values for loss of head was determined. Altogether 514 runs were made, comprising approximately 18,000 readings of gauges and weights.

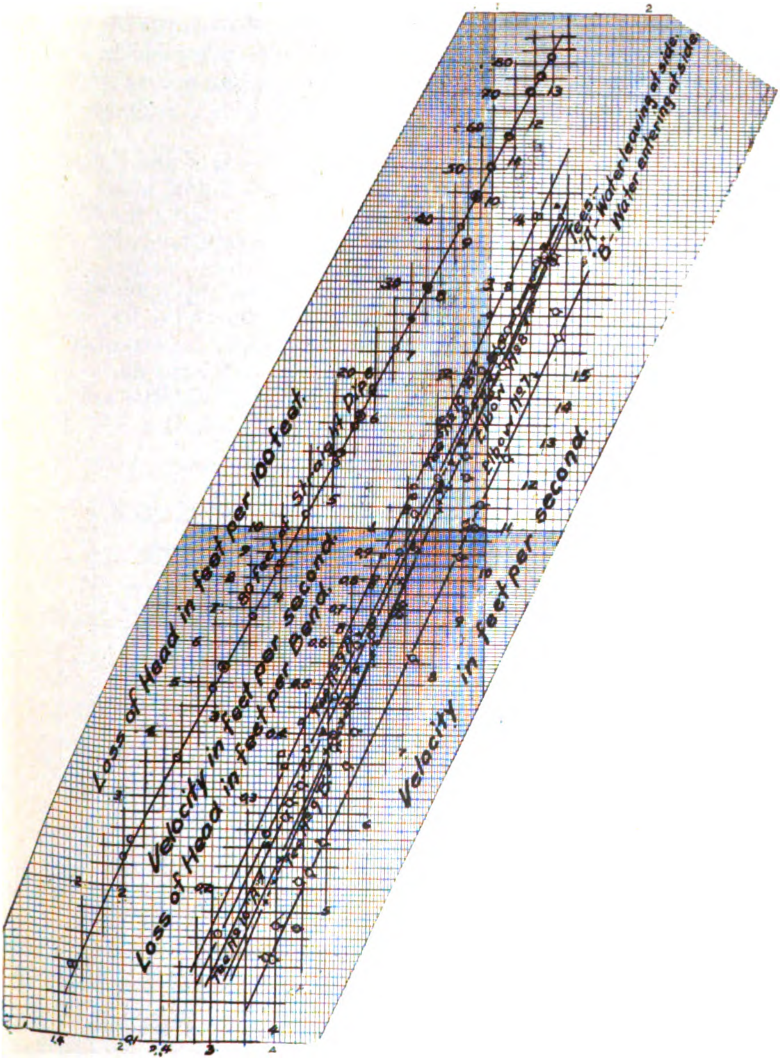

Loss of Head in feet per 100 feet.
80 feet of Straight Pipe
Velocity in feet per second.
Loss of Head in feet per Bend.
Velocity in feet per second.
Tees:
'A'- Water leaving at side.
'B'- Water entering at side.
Elbow
1.4
2
2.4
3
4
80
70
60
50
40
30
20
10
15
14
13
12
11
10
9
8
7
6
5

Fig. 3.

EFFECT OF STRAIGHT PIPE

The loss of head per 100 feet of straight pipe as determined by observing the loss of head over the 80.09 feet of straight pipe section is plotted in Fig. 3 as ordinates with velocity as abscissa. From these results it was found that the loss of head per 100 feet of straight pipe could be expressed by the exponential equation

$$h_l = 0.5965 \, V^{1.925}$$

where h_l represents head lost in feet of water and V represents velocity of flow in feet per second.

EFFECT ON CURVATURE

The losses of head observed across the bend experimental section included the loss of head due to the friction in 20 feet of the two tangents of straight pipe, the loss of head due to friction in the bend and the loss of head due to the change in direction of flow. From the observed loss of head an amount was subtracted equal to the loss of head

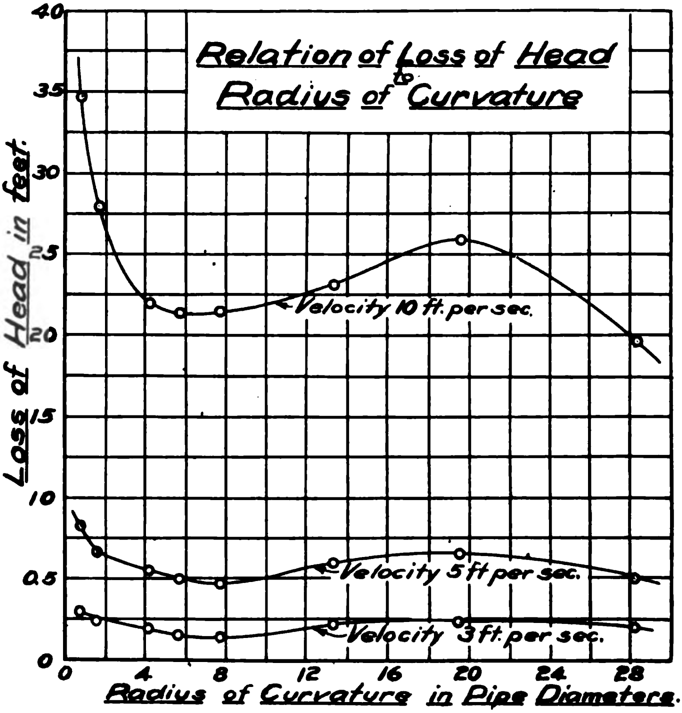


Fig 4.

which would occur for the same velocity in a length of straight pipe equal to the center line length of the bend section. The remaining quantity was the value of the excess loss of head due to curvature.

In Fig. 4 the curvature losses for velocities of 3, 5, and 10 feet per second are plotted as ordinates with the radius of curvature expressed in terms of pipe diameters as abscissae.

Fig. 4 indicates that the curvature loss is a minimum when the radius of curvature is 5 to 7 diameters, then reaches a maximum when the radius of curvature is about 20 diameters, beyond which point the loss decreases with increase of radius of curvature.

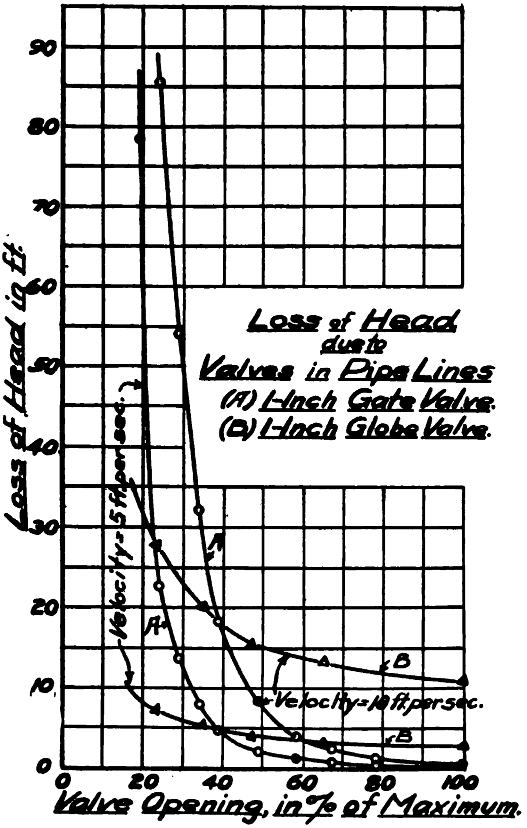


Fig. 5.

EFFECT OF VALVES

From the observed loss of head in the valve section, a quantity was subtracted equal to the loss of head in the 20 feet of the two lengths of pipe for the same velocity. The remaining quantity represented the loss of head due to the valve in the pipe line.

In Fig. 5 the losses in the gate and globe valves for velocities of 5 and 10 feet per second, obtained in the above manner, are plotted as ordinates with the valve opening expressed in per cent. of the maximum opening as abscissae.

From Fig. 5 we see that closing a gate valve does not greatly increase the resistance until it is 40 per cent. closed for a velocity of 10 feet per second or 60 per cent. closed for a velocity of 5 feet per second. The loss caused by a globe valve is much greater than that caused by a gate valve for wide open valves, but does not increase greatly until the valve is more nearly closed.

In Table A are tabulated the lengths of straight pipe which would give the same loss of head as obtained in the above manner for the gate and globe valves wide open and for the check valve with the check in place and with the check removed.

The loss of head in a gate valve wide open as compared to the loss of head in straight pipe decreases with an increase of velocity, while for the globe valve wide open and the check valve, the ratio increases with an increase of velocity.

From the last column in Table A, we find, for an average, that a gate valve is equivalent to about 8 diameters of straight pipe and that the globe valve wide open and the check valve are each equivalent to about 25 diameters of straight pipe.

EFFECT OF STANDARD ELBOWS AND TEES

If from the observed losses across the bend section the loss of head due to the 20 feet of the two tangents of straight pipe be subtracted the remaining quantity will be the value of the total loss of head due to the bend.

By inserting 90° elbows and tees instead of the bends the total loss of head caused by the elbows and tees was determined in the above manner. These total losses were plotted in Fig. 3 as ordinates with the velocities as abscissae.

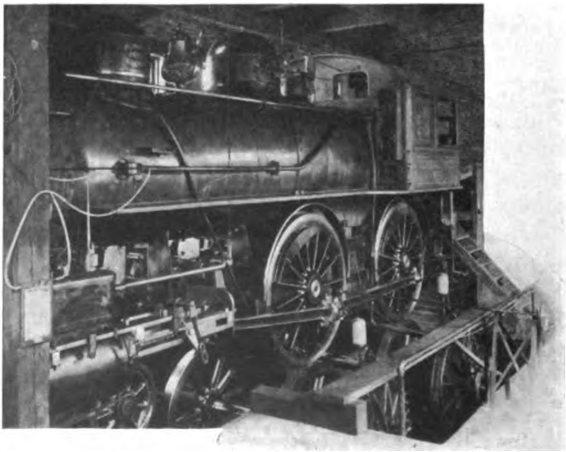
TABLE A—EQUIVALENT LENGTH OF STRAIGHT PIPE FOR LOSS OF HEAD IN VALVES AND STANDARD FITTINGS.

Velocity, feet per second		12	10	7	5	3	
Str. Pipe Loss per foot, feet		0.714	0.502	0.252	0.132	0.059	Avrg.
Gate Valve, wide open	Valve loss, feet	0.36	0.28	0.18	0.13	0.04	
	Equiv. length of Str. Pipe, in. feet	0.504	0.557	0.715	0.985	0.810	0.714
	Equiv. length of Str. Pipe, in. Pipe Diam.	5.9	6.5	8.3	11.5	9.4	8.3
Globe Valve, wide open	Valve loss, feet	15.60	10.80	5.32	2.76	0.96	
	Equiv. length of Str. Pipe, in. feet	2.19	2.15	2.11	2.09	1.96	2.10
	Equiv. length of Str. Pipe, in. Pipe Diam.	25.5	25.1	24.6	24.4	22.8	24.5
Check Valve	Valve loss, feet	16.30	11.30	5.58	2.88	1.02	
	Equiv. length of Str. Pipe, in. feet	2.28	2.25	2.21	2.18	2.08	2.20
	Equiv. length of Str. Pipe, in. Pipe diam.	26.2	25.9	25.4	25.1	24.1	25.3
Check Valve, check removed	Valve loss, feet	14.20	9.91	4.91	2.54	0.89	
	Equiv. length of Str. Pipe, in. feet	1.99	1.97	1.95	1.92	1.82	1.93
	Equiv. length of Str. Pipe, in. Pipe Diam.	22.9	22.7	22.5	22.1	21.0	22.2
St'd "Short Turn" 90° Elbow	Elbow loss, feet	2.75	1.80	0.795	0.370	0.115	
	Equiv. length of Str. Pipe, in. feet	3.85	3.59	3.16	2.80	2.35	3.15
	Equiv. length of Str. Pipe, in. Pipe Diam.	44.8	41.8	36.8	32.6	27.4	36.7
St'd "Long Turn" 90° Elbow	Elbow loss, feet	1.79	1.19	0.536	0.253	0.081	
	Equiv. length of Str. Pipe, in. feet	2.51	2.37	2.13	1.92	1.65	2.11
	Equiv. length of Str. Pipe, in. Pipe Diam.	29.2	27.6	24.8	22.4	19.2	24.6
St'd C. I. Tee, water leaving at side	Tee loss, feet	3.06	2.01	0.894	0.421	0.134	
	Equiv. length of Str. Pipe, in. feet	4.29	4.00	3.55	3.19	2.74	3.55
	Equiv. length of Str. Pipe, in. Pipe Diam.	50.0	46.6	41.3	37.2	31.9	41.4
St'd C. I. Tee, water entering at side	Tee loss, feet	3.80	2.52	1.12	0.530	0.169	
	Equiv. length of Str. Pipe, in. feet	5.32	5.02	4.44	4.02	3.45	4.45
	Equiv. length of Str. Pipe, in. Pipe Diam.	62.0	58.5	51.7	46.8	40.2	51.8
St'd C. I. "Long Sweep Special Tee," water leaving at side	Tee loss, feet	3.07	2.05	0.934	0.451	0.148	
	Equiv. length of Str. Pipe, in. feet	4.30	4.08	3.71	3.42	3.02	3.71
	Equiv. length of Str. Pipe, in. Pipe Diam.	50.1	47.6	43.3	39.9	35.2	43.2
St'd C. I. "Long Sweep Special Tee," water enter'g at side	Tee loss, feet	2.82	1.82	0.795	0.359	0.108	
	Equiv. length of Str. Pipe, in. feet	3.95	3.63	3.16	2.72	2.20	3.13
	Equiv. length of Str. Pipe, in. Pipe Diam.	46.0	42.3	36.8	31.7	25.4	36.4

The loss of head for velocities of 12, 10, 7, 5 and 3 feet per second was taken from Fig. 3 and tabulated in Table A. By dividing these losses by the loss of head per foot of straight pipe as determined by the 80.09 feet of straight pipe experiments for the same velocities, the equivalent length of straight pipe in feet was found. Dividing the value of feet of straight pipe by the average pipe diameter (1.0306 inches), the equivalent length of straight pipe in terms of pipe diameters was obtained, thus making the results comparable with results which may be obtained from pipe fittings of different diameters.

From Table A and Fig. 3, it is seen that the loss of head through the elbows and tees increases with a greater power of the velocity than does the loss of head through the straight pipe. Also from Table A, it becomes quite evident that the "long turn" elbow should be used in preference to the "short turn" elbow where the loss of head is an important consideration in the design of a pipe line.

Considering the tees, Table A and Fig. 3 show that with the ordinary standard tee the loss of head is less if the water leaves at the side than if the water enters at the side, being equal in the former case to that due to 30 to 50 diameters and in the latter case to that due to 40 to 62 diameters of straight pipe. With the "long sweep special" tee the opposite condition is found. In the case of the water leaving at the side the loss of head is equal to that due to 35 to 50 diameters of straight pipe, while in the second case the loss is equal to that due to 25 to 46 diameters of straight pipe.



Locomotive Testing Laboratory, Purdue University.

MODERNIZING A BOILER PLANT

By W. A. HANLEY, '11*

Synopsis: This article tells in detail how a small isolated boiler plant of approximately 700 boiler horsepower was enlarged and modernized so as to bring about a decrease in coal consumption of 22% and yield an interest of 38.5% on the investment necessary to produce the economies.

In undertaking the improvement of a boiler plant, the local conditions as to nature of service required, available equipment at hand, space for new equipment, coal supply, etc., are all factors which must enter into the final conclusion. That additional capacity was necessary, and that a saving in both labor and fuel could be made at the Indianapolis plant of Eli Lilly & Company, had been apparent for some time, and in the fall of 1912 the matter was taken under investigation.

The problem at hand was to supply 250,000 pounds to 350,000 pounds of saturated steam per day, with a maximum demand of 30,000 pounds per hour, not falling below 15,000 pounds per hour except at night, at a pressure of 120 pounds gauge, from 200 degrees Fahrenheit feed water. This steam was to be used for all general purposes throughout the plant, about 40 per cent. being taken in the central power house for generating electricity, compressing air, pumping water, etc., and 60 per cent. in heating, evaporating, drying and other processes throughout the laboratories.

The equipment at hand consisted of two type E–200 H. P. Stirling boilers in one battery, and a single unit of 300 H. P. of the same make and type. These boilers were connected into a brick lined steel stack 6 feet in diameter and 113 feet high, and were each equipped with an American Underfeed Stoker. Forced draft from an engine-driven fan was also piped under each furnace. An open type heater, hot water softener, and two boiler feed pumps were all found in good condition and of ample capacity. Nut coal from eastern Kentucky, having the same general characteristics as Pocahontas, and having a fuel value of 13,500 to 14,000 B. t. u. per pound, at a cost of $2.70 per ton delivered in front of boilers, was being used. The boilers were clean, settings tight, appliances in very good condition, and no local wastage of steam or coal was evident. Coal was hauled direct from cars or from storage yard in wagons, and was unloaded by hand into bins in boiler room, from where it was shoveled into hoppers of stokers. Ashes were dragged out from under boilers onto boiler room floor, and wheeled in barrows to alley adjacent to boiler room, where they were dumped. From this point they were reloaded into wagons and hauled to trash dumps.

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* Mech. Engineer, The Eli Lilley Co., Indianapolis, Ind.

The installation of a daily log, showing pounds of coal delivered to boiler room, number of boilers under fire, load variation, etc., was accomplished. At the same time a combined indicating and recording venturi meter was installed on the boiler feed line, and figures ascertained as to repairs and labor. Tests under operating conditions, over 8-hour and 10-hour periods, following the A. S. M. E. code, using a throttling calorimeter, and weighing the water and coal were then run on each of the three boilers, and on the boilers in pairs as they were operated. At the same time the venturi meter was checked and found to be correct to within 4 per cent. under extreme conditions of variation.

The tests and records showed the following to be true:

1st. That the boilers could not be operated above 95 per cent. of rated capacity.

2nd. That the fuel cost averaged 15.68 cents per 1,000 pounds of water evaporated under operating conditions.

3rd. That owing to limited capacity the 300 H. P. boiler must be in constant use, except on Sundays, and an accident to same would mean closing part of the plant.

4th. That owing to the absence of railroad switching facilities and a prohibitive cost to install same, the cost of handling coal could not be decreased.

5th. That the cost of handling ashes could be materially reduced, and a large part of the energy used to drive stokers and draft fan could be saved.

6th. That cost for repairs had not been excessive and could not be lowered an appreciable amount.

With the above facts well established it was therefore determined to install such equipment as would give additional boiler capacity, lower evaporation cost for fuel, lower ash handling costs, and reduce the energy consumed in stoker and fan drives.

An addition was made to the boiler room of sufficient size to accommodate a battery of type L-16 312 H. P. Stirling boilers, and one-half the battery, that is, one boiler of 312 H. P., was installed. As Indiana screenings offered the greatest number of available heat units for the least amount of money, and as satisfactory guarantees both as to efficiency and capacity could be obtained from reliable stoker companies, it was decided to use such fuel.

A contract was made with the Green Engineering Company, of Chicago, Illinois, to remove the old stokers and install chain grate stokers and high pressure water backs on each boiler, remodel and re-line the furnaces, rebuild the fronts of boilers, construct an ash tunnel under boilers, and install a bucket ash conveyor and ash bin at the end of boiler room. Their contract also covered the installation of a drive for stokers and the brick work and breeching connection on the new type L-16 Stirling boiler. Practically the entire work and all details were covered in this contract except steam and water piping and electrical wiring. All the work had to be done without interfering with the operation of the plant, and the work under boilers as to tunnel, et., was accomplished while the boilers were under fire.

The concrete tunnel under boiler room was made 8 feet wide and 8 feet high. The ash pits were made exceptionally large. A dumping ash cart on a narrow gauge track passed in front of the ash door under each boiler. The track terminated in a boot at the end of boiler room, where the ashes were dumped and hoisted to the ash bin outside the building. This bin was of sufficient capacity to carry three days' supply of ashes and was elevated so that wagons could drive under same and load by opening a gate in bottom of bin. The ash tunnel ceiling carried the shafting for driving the stokers. The stokers were driven by two units both located on boiler room floor, one being a 7½ H. P. 50 per cent. variable speed motor and the other a 5″ x 6″ vertical steam engine. As a matter of safety it was considered necessary to install two units, and as electricity was not available on certain nights and Sundays it was necessary to install the engine, the motor being used under all other conditions.

The furnaces were reconstructed and made of the Dutch oven type with deep ignition arches, and the high pressure water backs were made of extra heavy 5-inch pipe and equipped with GECO fittings. Ample provision was made under the furnaces for the recovery on boiler room floor of droppings from grates. The ash conveyor was driven by a 5-inch by 6-inch vertical steam engine, being the same size and type as the auxiliary stoker drive. As ashes were to be handled at night, electricity would not be available for driving a motor at that time. The breeching to the new boiler was made as large and with as wide sweep bends as possible.

The guarantees as set forth in the contract with the Green Engineering Company are quoted below as follows:

"The contractor will give guarantee the following results, when furnished with coal of at least 10,000 B. t. u. and a draft of not less than 3-10 inch of water in the furnace over the fire:

(1) To maintain an efficiency of approximately 68 per cent. under operating conditions, the stokers being fired under contractor's instructions.

(2) To obtain an overload capacity of 30 per cent.

(3) To eliminate smoke so as to conform to the Indianapolis smoke ordinance.

(4) That the cost of metal repair parts for stokers will not exceed $20.00 per stoker per year for a period of 3 years, and that the metal repair parts purchased will not cost to exceed $50.00 per ton."

In order to obtain the required draft it was found necessary to increase the height of the stack by 50 feet, making it 163 feet high. This was done by another contractor with the stack in constant use, after some preliminary work had been done as follows: On the first Sunday the ornamental top and water table were removed, on the second Sunday a six-foot steel section was added with an opening in the side of same to allow smoke to escape, and on the third Sunday another six-foot section was added with a steel plate in bottom of same thus closing completely the top of the stack. Thereafter the work was carried on with the stack in use, and when the full 50 feet had been added, the sheet closing the top, above referred to, was removed and the side opening covered.

To complete the entire installation of new stokers, etc., required a period of about six months. At the end of such time an acceptance test, under ordinary operating conditions, was run on each boiler. With Indiana screenings of about 11,000 B. t. u. per pound an overall efficiency of 70 per cent. was obtained, and a capacity of 75 per cent. overload developed on each boiler.

In order to determine what coal could be used most economically, a series of ten steaming tests, under operating conditions, covering periods of 6 hours to 10 hours were made, using various grades of Indiana and Illinois screenings. A careful comparison showed that coal furnished by the Garstang Fuel Company, of Indianapolis, Indiana, and mined by the S. W. Little Coal Company, of Evansville, Indiana, by analysis and by test should be used. Some better and some poorer grades of coal were tested, but at relatively higher prices. The general characteristics of this coal from a large number of analyses made in our own laboratories at different seasons of the year shows it to be as follows:

1¼ inches Nut and Slack coal from No. 5 vein, Pike County, Indiana.

V. C. M.	25.86 per cent.
Fixed Carbon	48.98 per cent.
Moisture	11.58 per cent.
Ash	13.58 per cent.
Calculated value B. t. u. per lb.	11,270

Statistics for the first year after this installation was complete showed that 91,775,000 pounds of water had been evaporated, at a fuel cost of 12.21 cents per thousand pounds, which represented 3.47 cents saving per thousand pounds or a total of $3,183.90 on fuel alone. In addition to the above the savings in labor for hauling and handling ashes were $140, and the saving in steam for fan and stoker drives $200, making a total return from the investment of $3,523.90 for the year. Repairs have been very little, but no actual saving can be counted on this item as the same may increase with the age of the installation. The total expenditures for building, boilers, stokers, stack, and equipment represented about $25,000. Of this, $14,500 was spent to increase capacity and $10,500 to produce economies. The gross return, therefore, of $3,523.90 per annum on the $10,500 expenditure represented 33.5 per cent.

The boilers have been operated at from 50 per cent. to 75 per cent. above capacity at all times, as this has been found to be most economical. No delays or failures in service have been experienced, and the smoke ordinance has been fully complied with.

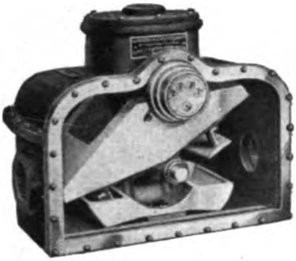
CONDENSATION METERS

By W. T. MILLER, '16

Synopsis: Three methods of metering steam heat to consumers of central station heat are explained. The condensation meter is rapidly replacing other methods and is giving very satisfactory service. These meters are of two types: the weight and the volumetric. The operation, care, faults, and advantages of each are discussed in this article.

The most important phase of central station steam heating work is selling heat. There are in common practice today two methods of disposing of the product; the flat rate, based on square feet of radiation, and, a schedule rate based on the actual amount of steam condensed in the particular system.

In the younger days of central station steam heating, it was realized that the logical way to sell service was to base the rates upon actual consumption, but the methods of measuring the quantities of steam supplied to various customers were very crude and led to unwarrantable errors. The difficulty experienced in determining a fair approximation at the steam supplied, led to the adoption of a flat rate which was originally based on the cubical contents of the building to be heated. This method made no allowance for the exposed walls, window or glass surface and proved unsatisfactory because of this fact. The original flat rate evolved into a rate based on the number of square feet of radiation installed. The rate per square foot was based on an assumption as to the quantity of steam condensed per square foot per season. As exposed wall and glass areas were considered when the number of square feet of radiation was computed, this method of determining the rate was fairer to the consumer and producer than the earlier one. However, there is a personal element which entered into the problem in that some consumers through carelessness may cause the rate of condensation per square foot of radiation to rise a considerable amount above that upon which the rates were based. Again, a careful customer might cause the rate of condensation to become considerably lower than that for which he was paying. While the average may be near the rate assumed, the careful customer was paying for the negligence of the other. In order to eliminate this fault, the greater number of companies are at the present time adopting a schedule based on the actual amount of steam supplied to each individual consumer. This scheme has been made possible by the perfection and simplification of devices for measuring the flow of steam and condensation.



Dump Bucket Type Meter.

There are several meters on the market designed to measure the flow of steam. These meters are, by merit of their fundamental principles, divided into two classes; those depending upon a constant velocity of steam, and those based on a constant supply area. Meters of both types have been perfected but are necessarily of a rather delicate construction; this means that they are somewhat costly and that they require considerable attention. These facts limit their general use to power plants and large consumers of steam, since the initial cost and cost of maintenance prohibits them from being supplied to numerous small consumers.

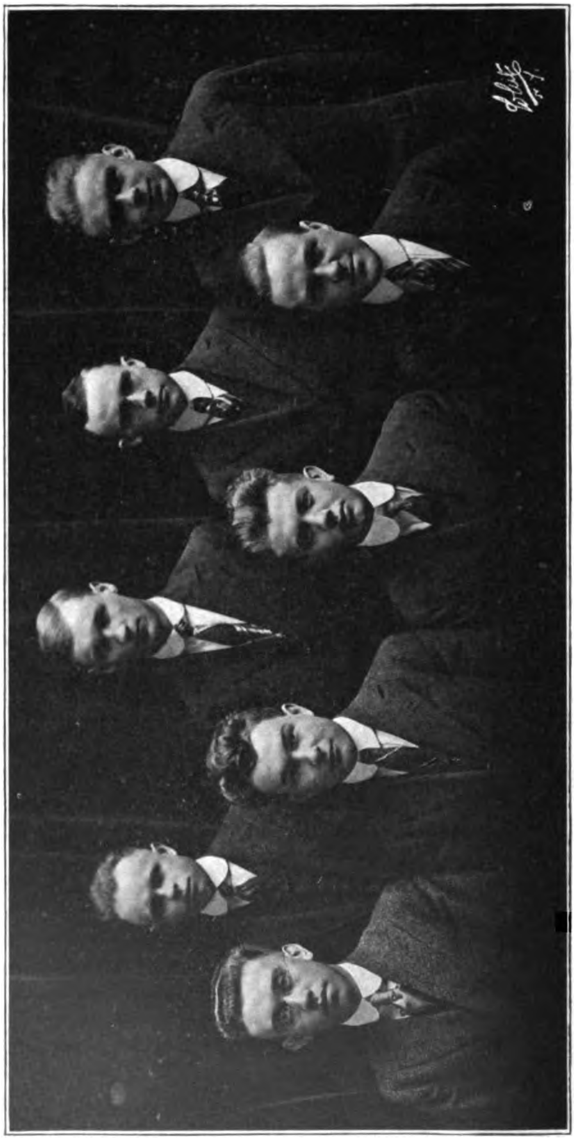
The condensation meter solves, to a great extent, the problem of providing a cheap and sufficiently accurate means of measuring the steam supplied to small consumers. Since the perfection of this type of meter, the central station steam heating industry has made its greatest strides. Condensation meters are primarily gravity meters and cannot discharge against pressure. Three principles of operation are incorporated in the condensation meters commonly used by central station heating companies; those that are based upon volumetric measurement, those that record the weight of fluid passing through it, and those that are based on the trap principle. Of these types the volumetric and weight meters are the most common due to their simplicity. Perhaps the most common of the weight meters is the Simplex, while the most popular of the volumetric meters is the Detroit.

The Simplex meter is of the dump bucket type, and has two buckets balanced on a shaft which rocks as they alternately fill and dump. The condensation enters into a receiving chamber where the stream is divided by means of a baffle plate in order that the velocity may be diminished. From the receiving chamber the condensation passes through a nozzle and flows in a thin stream into the main chamber of the meter where the partition between the buckets deflects it into the bucket that is being filled. As the bucket fills, the increase in weight causes it to overbalance the empty bucket and it falls into a position that permits the condensation to flow into the bottom of the main chamber from which it is drained through an outlet at either end. A plunger is attached to the bottom of each bucket which fits into a corresponding dash pot fixed to the bottom of the meter. These dash pots are filled with water at all times and the cushion action tends to make the action of the meter noiseless. A set screw is provided by means of which the travel of the buckets may be regulated, thereby controlling the capacity of the buckets. A revolution counter records the oscillations and reads in pounds of condensed steam. The shaft is supported at each end by means of bronze cones and cups in which bronze balls are used. The bearings are supported in removable caps attached to the meter case. These meters are calibrated to operate at a temperature of about 180 degrees F. The error involved at rated capacities is very small but the impact effect of the condensation entering the buckets causes a noticeable error when the meter is operated at overloads and at exceptionally light loads.

The Detroit meter is of the revolving drum type, and its mechanism consists of a cylindrical copper drum which is divided into six scroll shaped compartments. A brass spout which is attached to the meter case but not to the drum admits the condensation. In the bottom of the spout and extending its entire length is the inlet opening through which the condensation is admitted in a thin stream to each compartment of the drum as it rotates. Due to the shape of the compartments and to the fact that any one compartment cannot fill and discharge at the same time, any change in the volume or velocity of the incoming condensation cannot affect the discharge and consequently cannot affect the accuracy of the meter. The compartments are exactly the same size, and as each receives and discharges the same volume of water at each revolution, the same quantity of condensation passes through the drum at each revolution. When the inflow of water stops, the motion of the drum ceases and the water in the compartments remains there until the flow is resumed. The drum is made of sheet copper and is very rigid in construction. The bearings which support the drum consist of hard bronze flanges which are soldered to the drum. These flanges are supported by bronze rollers held in cast bronze brackets mounted inside the cast iron casing. The registering device consists of a clockwork revolution counter which reads in pounds of condensation per revolution. The clockwork is protected by a glass dial and is enclosed in a housing that is cast integral with the casing. The meter is calibrated for a temperature of about 140 degrees F. and is accurate with 1% at all loads. This meter is adapted to vacuum service when used in connection with a vacuum trap.

The faults to be found in the operation of condensation meters are usually due to lack of care in their installation and maintenance. As condensation meters are more apt to read under than over, it is to the interest of the operating companies to maintain a rigid system of maintenance and inspection. All meters should be overhauled, cleaned and calibrated at least once each year.

Perhaps one of the most serious handicaps on hot water central station heating is the fact that no suitable means of metering the heat has been perfected. Devices for registering the comparatively small differences in temperature and pressure would be necessarily very delicate and hence too costly to warrant an elaborate installation. Could a simple and hardy device be perfected to register these differences, the results might be more satisfactory than those now obtained through the use of condensation meters in the steam systems, as the chief objection to their use is that the condensation may be diverted or lost before it reaches the meter.



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THE ENGINEERING REVIEW STAFF

The Purdue Engineering Review

No. 12 PURDUE UNIVERSITY May, 1916

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The splendid support that the Alumni of Purdue University are giving to the *Review* is reflected very well by the list of contributors to the publication this year. Never since the call has been made for papers has the response been more prompt and the material so plentiful, and it is with distinct regret that we are unable to publish all the good articles that were offered us this year. When so many busy men, who are constantly being pushed by the cares and responsibilities of business, as many Purdue men are, offer to take the time and go to the trouble of working up a paper for publication in the *Review,* we feel decidedly encouraged and feel that the Alumni body in general appreciates the work that the *Review* is doing and the place that it is trying to fill.

The *Engineering Review* is the journal of the Engineering Societies of Purdue University. It is published by their Board for the purpose of advertising Purdue and the kind of work that Purdue men are doing as engineers in different parts of the world. The publication reaches the members of the Engineering Societies of the Central and Middle Western States, the engineering students of several of the leading technical universities, in addition to several hundred business firms in all parts of the country.

Department Notes

SCHOOL OF ELECTRICAL ENGINEERING

PERSONNEL

Little change has been made in the staff of the School of Electrical Engineering during the past year, as the organization for the year 1914-15 was considered to be a particularly strong one. One assistant, Mr. G. C. Blalock, was added to the corps making a total of thirteen. Mr. Blalock is a graduate of the University of Michigan in Electrical Engineering and since graduation has obtained some valuable experience on the Electrical Engineering staff of the Municipal Board of the city of Los Angeles, California. Professor A. N. Topping, who for a number of years has been in charge of the Junior work and specialized work in illuminating engineering, has been made full professor of Electrical Engineering. Professor Alfred Still is now professor of Electrical Design. Mr. D. L. Curtner has been advanced from the grade of assistant to that of instructor during the past year.

Professor C. Francis Harding, head of the school, has continued to act during the year as chairman of the subcommittee on Technical Education of the National Electric Light Association and represented the Indiana Engineering Society at the recent conference of representatives of State Engineering Societies, looking toward closer co-operation between such organizations.

CHANGE OF COURSE

Some marked improvements have been made in the course in Electrical Engineering during this year, involving the completion of the work in mathematics at the middle of the Junior year, thereby permitting more work in applied Electrical Engineering to be administered to Juniors. The Senior course in Corporate Organizations which offers training in the organization, management and financial relations of corporations will be required work for the second semester during the coming year while the elective courses will be confined to the first semester of the Senior year.

RESEARCH

A large amount of research work has been carried on during the past year in the School of Electrical Engineering, particularly with regard to the testing of very high voltage insulators and interference between high voltage lines and parallel telephone lines. The latter problem, which is becoming of much practical importance with the increase in the number and voltage of transmission lines, is being studied with respect to both the experimental line at the University and some long transmission lines in practical operation. The results of this work together with that in the electric railway field are being published in the proceedings of the various engineering societies and in the technical press.

SCHOOL OF CIVIL ENGINEERING

PERSONNEL

The resignation of R. L. Sackett, who is now Dean of the Engineering Schools at Penn. State College, was regretted by the faculty of the School of Civil Engineering. Professor Sackett's work is being cared for by Professor Wiley and Mr. Greve, assisted by Mr. C. C. Brown, a practicing engineer and also Editor of Municipal Engineering at Indianapolis. Mr. Brown was formerly Professor of Civil Engineering at Union College, Schenectady, N. Y., and consulting engineer for the New York State Board of Health.

Mr. R. C. Pierce, graduate of the University of Illinois, and formerly with the Reclamation Service, was appointed Instructor in Civil Engineering.

LABORATORY FOR TESTING MATERIALS

Professor Scofield has installed a special testing apparatus for determining the most efficient design of reinforcing material for concrete roads. A slab is uniformly loaded with a testing pad under air pressure, and the consequent deformation and deflection throughout the entire slab are measured.

Professor Martin has determined the flexural strength of road sections made up of a concrete base with a brick top as compared to a solid concrete road.

Professor Albert Smith has continued his painstaking investigations of the distribution of stresses throughout riveted steel joints to determine the slipping point of the rivets and the proportionate share of the load carried by the various rivets. In this work the deformation throughout the entire joint is indicated by the rotation of small mirrors.

Professor Scofield in co-operation with Professor Wallace of the School of Mechanical Engineering, has been investigating the strength of side frames for railway cars. A survey of the deformation is made throughout the entire side frame with a view to economic design.

The laboratory has rendered service to the Indiana Sand and Gravel Producers' Association by determining the most efficient division plane between the fine and coarse aggregates, screened from gravels for use in concrete. The present practice calls for this division between sand and gravel on a sieve with ¼-inch openings. It has been determined that a screen with ⅛-inch openings will yield as strong a concrete in many cases and will make use, without waste, of nearly the entire output of the gravel beds as found in many places in Indiana. In conjunction with Professor Peffer of the School of Chemical Engineering, a series of tests is under way to discover the most efficient materials with which to protect concrete against disintegrating agencies.

HYDRAULIC LABORATORY

The determination of the loss of head due to the flow of water through one-inch straight pipe, elbows, bends, valves and special fittings has been completed. The investigation is being continued during the present year on 1½-inch pipe by Mr. Greve and Mr. Stanley.

TOPOGRAPHICAL ENGINEERING

For the first time, the School of Civil Engineering has taught the elements of the use of the transit and level in marking out straight and level lines to Juniors in the School of Mechanical Engineering. These exercises are a portion of the course in Junior Laboratory. The student reports for five afternoons during the semester. It is not expected that these men will obtain competency in the use of the instruments in field work of civil engineering. They will be able to lay out factory buildings, foundations and line up shafting.

The Engineering Camp for the summer of 1915 was held at Pentwater, Michigan, from May 29 to July 3. Pentwater is a town of about 1,200 inhabitants on the east shore of Lake Michigan, about 270 miles north of Lafayette. The camp was attended by sixty-five students, five instructors, one janitor and three cooks. The cost for board and lodging approximated $5.00 per week. The entire cost to each student was less than $40.00. Last year's success has led to arrangements for the 1915 camp at Pentwater for a period of six weeks. The school is considering plans for a permanent surveying camp on land owned by the University on which a permanent building can be erected.

HIGHWAY ENGINEERING

Professor Martin has held one district road school, and four county road schools in the State, each one attended by over fifty persons, together with about fifteen community meetings. Continued service has been given to road officials in advice upon road problems. Several field experiments in road building are under way in co-operation with the U. S. Office of Public Roads. Professor Martin has published one bulletin on road maintenance, and two leaflets on gravel roads and the use of the road drag. The official state road school was unusually successful this year, being attended by over sixty state officials. The School of Civil Engineering is serving the State of Indiana in a thorough way in Highway Engineering.

SCHOOL OF CHEMICAL ENGINEERING

This school has enjoyed a year of very satisfactory growth, characterized by such a heavy demand for the services of graduates that only a portion of the available openings could be filled.

The new plan of administration of mathematics for the engineering schools, whereby the latter subject is completed in the first semester of the Junior year, has permitted of the further improvement of the curriculum of this school by the introduction of a course in Physical Chemistry in the Senior year.

During the year additional work has been done along the line of investigating the action of organic acids and salts on concrete, as well as on methods for the measurement of film thickness of lubricating oils. Other work in progress at the present time consists in an investigation of the effect of various substances on the setting time and other properties of finely ground cement clinker, also a survey of the combustion conditions in a boiler furnace.

SCHOOL OF MECHANICAL ENGINEERING

A brief account of the year's work in the Department of Mechanical Engineering for the past year may be summarized under four heads:

PHYSICAL GROWTH

During the year the department has had the temporary use of $1400 worth of apparatus. New equipment to the value of $2360 has been added to laboratory apparatus, while friends of the University have made unsolicited donations of $2900 worth of valuable equipment either for test, exhibition or routine laboratory work.

RESEARCH

Fifteen lines of research were completed far enough to be worthy of publishing, while twenty problems are still under investigation. The value of the research work is increasing each year due to more thought and planning on the part of the instructors of the department. Fifteen articles were published in engineering journals and proceedings of engineering societies last year, dealing with modern problems. Twelve notes and text books were also published for instructional purposes in this and other institutions of learning by members of this department.

CHANGES IN INSTRUCTIONAL STAFF

Three members of the department resigned to take up more responsible positions. Mr. J. L. Snyder, instructor in the Mechanical Laboratory, and Mr. H. L. Watson, Instructor in Machine Design, are now connected with commercial organizations, and Mr. R. L. Rhoades was called to Lehigh University as Instructor in the Mechanical Laboratory. The vacancies caused by these withdrawals have been filled, respectively by Mr. F. A. Hill, Iowa State College, 1913; Mr. F. C. Goldsmith, Purdue, 1910; and Mr. W. H. Severns, University of Kansas, 1914. The personnel of the instructional staff of this department numbers nine professors, six instructors and two assistants.

INTERESTING WORK NOW IN PROGRESS

At the present time some very interesting work is in progress. The new Diehl electric dynamometer in the gas laboratory makes possible some interesting work on internal combustion motors. The new six-cylinder Haynes motor is now being tested in comparison with a Haynes 12, now under construction at Kokomo. The completion of the belt testing machine makes the best apparatus of this kind ever constructed ready for use. An investigation is now under way in which five of the large pulley manufacturing companies are concerned. Work is still progressing on the flat spot machine, studying the amount of impact to the rail due to a flat spot or an eccentric car wheel. Another interesting study is being made for the New York Central Railroad to learn what effect the use of impure water has on the steaming properties of a locomotive boiler. A new freight locomotive was brought here and tested at Purdue University and is returning to the University every thirty days to be retested. This locomotive uses the same kind of water the other twenty-nine days during which it is on its regular run. This will be continued until the boiler is so badly scaled as not to be able to carry its allotted load.

Many other lines of work are in progress but the ones mentioned are creating the most interest in engineering circles.

The business policy of the *Review* in years past has been to get out a publication that would exactly break even financially. In several recent issues unlooked for expenditures arose, which meant that a debt had to be carried over from year to year to be met by the succeeding staff. This old debt was swept away by a special assessment on the Engineering Societies, so that the *Board* began the year unincumbered by any financial burden. It has been the very earnest endeavor of the *Board* to get out a publication this year that would be a success from a business standpoint, that would set a mark and a precedent for succeeding Boards to follow.

The *Review Board* desires to acknowledge the services of the following members of the Engineering Schools: C. L. Kline, Marvin Hummel, J. H. Emrick, Geo. Heidenreich, H. M. Benedict, O. W. Shepard, R. H. Bush, and to Mr. D. M. Evans of the School of Agriculture for valuable assistance rendered the Advertising Manager in the solicitation of advertising.

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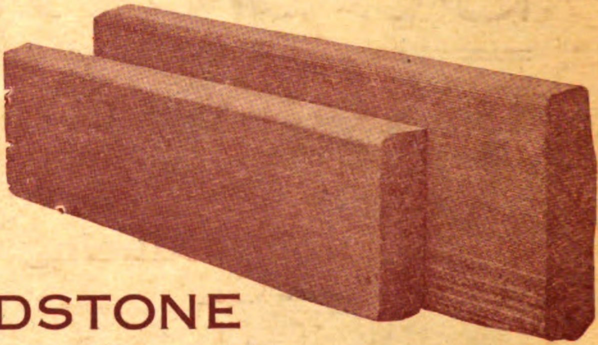

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The Purdue
ENGINEERING REVIEW

PURDUE UNIVERSITY
1917

No. 13

MAY, 1917

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Number 13
1917

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Engineering Review Authors for 1917

MR. H. W. ASIRE B. S. E. E., '14, (*"Flywheel Type Magneto"*) until the year 1916 was Ass't Electrical Engineer with the Knoblock-Heideman Mfg. Co. From 1916 to the present time he has been Electrical Engineer for the Quick Action Ignition Co. Mr. Asire is an associate member of the A. A. E. and A. I. E. E.

MR. E. A. BECK, B. S. C. E., '13, (*"Street Improvement Planning in Edgeworth, Pa."*) is Borough Manager of Edgeworth, Pa. That he has been successful in this new field is shown by his recent contribution to the technical press.

MR. R. J. BUCK, B. S. C. E. '07, C. E. '10, (*"Construction Work in the Philippine Islands"*) from 1907-09 was Transitman and later Chief of Party of the Bureau of Lands (Gov. of P. I.); 1909-10 Ass't Instructor in the C. E. Department of Purdue University; 1910-12 Chief of Party, Bureau of Lands; 1912-14 Ass't Engineer, Bureau of Public Works; 1914-16 member of firm of the J. W. Ford Co.; and from 1916 to the present time, Superintendent of Construction of the Marion Co. Tuberculosis Sanitarium. He is also an associate member of the A. S. C. E.

MR. ARTHUR C. EMBSHOFF, B. S. Ch. E. '16, (*"Milling and Flotation"*) during 1913-14 served as chief of party on various survey and construction jobs in Arizona, 1914-15 was Junior Engineer on Gila River flood prevention surveys, and until lately he has been employed by the Butte and Suprior Co. of Butte, Mont. Mr. Embshoff is now night superintendent of the mine and development work of the Lead & Zinc Co., Metaline Falls, Wash. He is a member of the A. A. E.

MR. F. C. HUFFMAN, B. S. C. E. '05, (*"Construction of Grain Elevators"*) was an Ass't Engineer with the Penn. R. R., resident engineer with the C. C. C. & St. L. Ry., 1906-08, Ass't Engineer with the C. & N. W. R. R., 1908-09, Ass't State Engineer of South Dakota, and 1909 to date, resident engineer with the C. & N. W. Ry.

MR. J. CLIFFORD LEWIS, B. S. M. E. '09, M. E. '16, (*"Making a Profit from Exhaust Steam"*) from 1909-11 was Erecting Engineer for the American Blower Co., Detroit; 1911-12, in charge of the St. Louis branch of Hanley-Casey Co., heating contractors; 1912-16, Chief Engineer for Weinshank & Fenstermaker, Indianapolis; 1916 to date, Consulting Engineer. He is a member of A. S. H. & V. E. and A. S. M. E.

MR. H. M. LUKENS, B. S. C. E. '12, (*"Flood Protection and Prevention in Los Angeles County"*) was building inspector of the I. C. R. R. from 1912-13, 1913-16 was engaged in private practice at Gary, Ind., 1916-Jan. 1917, was an engineer on the Los Angeles flood control project, and at present is an engineer of the Wurster Construction Co.

MR. E. S. PEARCE, B. S. M. E. '13, (*"Increasing the Utility of Existing Locomotives"*) was Mechanical Draftsman with the J. T. Reyerson & Sons, Motive Power Inspector of the N. Y. C. R. R., and since 1914, has been with the C., C. C. & St. L. Ry., being at present special engineer in the Transportation Department.

MR. E. G. RALSTON, B. S. E. E. '13, (*"Rates for Electric Lighting and Power"*), after graduation entered the Construction and Testing Department of the Indianapolis Light and Heat Co., and since 1915 has been an Electrical Engineer with that firm. Mr. Ralston, son of Gov. Ralston, of Indiana, is a member of the Indiana Engineering Society and the Indiana Electric Light Association, and has recently presented several papers before engineering societies.

MR. FRANK SCOTT, B. S. E. E. '16, (*"Damage to Operating Companies Caused by Lightning"*) after graduation entered the employment of the Duncan Electric Mfg. Co., of LaFayette, Ind., as Chief Tester in the Transformer and Meter Department, being later advanced to Superintendent of the Transformer Factory, which position he now holds.

MR. R. S. SHADE, B. S. M. E. '12, (*"Meters for Measuring Gas and Air Volumes"*) From 1910-12 was Industrial Service Secretary at the University of Pennsylvania Y. M. C. A.; 1912-17, Superintendent of Construction and Distribution of the Kansas Natural Gas Co. In 1915 the partnership of Clark & Shade, Consulting Engineers was formed.

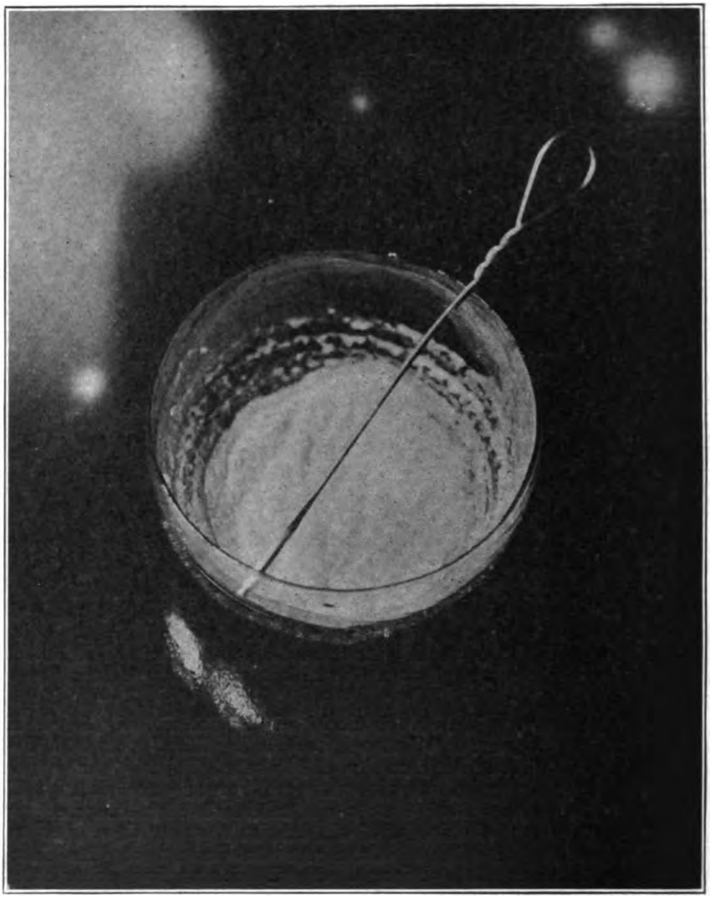
MR. J. B. SHEADEL, B. S. E. E. '11, (*"High Voltage Line Insulators"*), from 1911-12 was employed by the Bullock Electric Co., Cincinnati, O., was an assistant instructor in the School of Electrical Enginering, Pennsylvania University, and from 1913 to date he has been an assistant instructor in the School of Electrical Engineering, Purdue University.

MR. E. A. SMITH, B. S. C. E. '12, (*"The Construction of Lock and Dam No.* 43, *Ohio River"*), has been with the U. S. War Department since graduation, as surveyor 1912-16 and as Junior Engineer since 1916. He has designed several locks and operating machinery, and has served as superintendent of construction.

PROF. G. A. YOUNG, B. S. M. E. '99, M. E. '04, M. M. E. '10, (*"A Brief Review of Twenty-five Boiler Tests"*), in 1899 became assistant in the Laboratory of Purdue, in 1910 was made Professor of Mechanical Engineering at Purdue, and from 1913 to date has been head of the School of Mechanical Engineering at this institution. During 1911-12, he had supervision over an acceptance test of 14000 K. W. turbine and boilers for the Commonwealth Edison Co., Chicago. Prof. Young has contributed many papers to the technical press and is a member of A. S. M. E., Indiana Engineering Society, Academy of Science, and various other organizations.

MR. C. H. VIOL, B. S. Ch. E. '07, Ph. D. '12, (*"The Production and Uses of Radium"*), from 1907-09 was Chemistry instructor at South Dakota State College, 1909-12 Research Ass't. in Chemistry at University of Chicago, was Research Chemist with the Standard Chemical Co. of Pittsburg, becoming Director of the Radium Research Laboratory in 1913. Mr. Viol is a member of the Am. Ch. Society, Am. Electro-Ch. Society, Am. Radium Society, and several other organizations. He is also editor of "Radium."

MR. H. A. WOODWORTH, B. S. M. E. '09, M. E. '13, (*"Central Station Steam Heating"*), from 1909-16 was employed in the construction and operation departments of the Central Station Heating plants at Crawfordsville and Evansville, Ind. From 1916, he has been a salesman for the American District Steam Co. Mr. Woodworth is a Senior member of the N. D. H. A. and has contributed frequently to the technical press.



This illustration is reproduced from a photograph of a dish of radium bromide. (The photograph of the radium salt was made shortly after the salt had been crystallized and dried. Under these conditions the beta and gamma ray activity of the radium was at a minimum and therefore the photographic plate could be brought near the preparation without risk of fogging). The small silica capsule which is shown in its natural size, contains 1764 mgm. of anhydrous radium barium bromide having a radium element content of 740 mgm. (International gamma ray Standard). Since pure anhydrous bromide contains 58.6 per cent. of radium element, the 740 milligrams of radium correspond to 1263 milligrams of pure anhydrous radium bromide, and the salt shown is 71.6 per cent. pure radium bromide. The radium shown in the dish represents months of work on upwards of three hundred tons of Colorado carnotite ore. In the process of extracting this radium over five hundred tons of chemicals

PURDUE
ENGINEERING REVIEW

No. 13 PURDUE UNIVERSITY 1916-1917

THE PRODUCTION AND USES OF RADIUM.

Charles H. Viol, B. S., Ph. D.

Director Radium Research Laboratory, Standard Chemical Company,
Pittsburgh, Pa.

Despite unfavorable market conditions brought about by the war abroad, and by opposition on the part of the Bureau of Mines, the production of radium in the United States is an infant industry that has outlived its early hardships. To-day the United States not only has the largest supply of radium ore, but also ranks as the world's largest radium producer.

The remarkable property of radium is its radio-activity, a property depending upon the breaking down of the atoms of radium with the emission of energy in the form of the so-called radio-active rays, and the production of new elementary substances. As a result of an almost incredible amount of research, the work of many scientists, it has been demonstrated that uranium is the parent element of a series of radio-active substances which are produced successively by a process of transmutation, the uranium-radium series consisting of the following numbers: Uranium I, Uranium X_1, Uranium X_2, Uranium II, Ionium, Radium, Radium Emanation, Radium A, RaB, Ra C, Ra C_1, Ra C_2, Ra D, Ra E, Ra F (polonium), and a final non-radio-active substance Ra G, chemically identical with ordinary lead. All of these products are found in any geologically old ore containing uranium, the proportionate amount of each product depending upon the rate at which the radio element is undergoing the process of transmutation or decay. The rates of decay of the radio elements are definite for each

---

were used, exclusive of water. When one considers the enormous difficulties and expense in extracting this small quantity of radium salt from such huge amounts of material, it is possible to realize why radium salts are so costly. At the rate of $100 per milligram of radium element, which is equivalent to a rate of $53.60 per milligram of pure crystalline radium bromide, ($Ra Br_2 2H_2O$, the pure "radium" of commerce in the past), the radium shown in the dish has a value of $74,000.

element, and so far, it has not been found possible to alter the rates by subjecting the substances to any conditions. Unlike ordinary chemical changes, the changes in the radio-active bodies are unaffected by change of temperature, pressure or concentration. For each three million parts of uranium in an old unaltered ore, there is one part of radium. Consequently for each per cent. of uranium oxide (U_3O_8) in a ton of uranium ore, there are 2.5 milligrams of radium element.

Radium of the radio elements of the uranium-radium series, has come to be of more commercial importance than the other members of the series, owing to the fact that it is undergoing the transmutation process rather slowly, requiring 1700 years for the decay of half of any quantity, while the subsequent products, Radium Emanation, Ra A, Ra B and the complex Ra C, are all undergoing a very rapid process of transmutation, resulting in the rapid emission of a succession of rays from each of these products for each atom of radium that transforms. Thus, a radium preparation has the long life of radium, and the high degree of radio-activity contributed by the rapid transmutation of the successive decay products of radium. No other radio-element combines these two advantages in the same degree, the nearest competitor, mesothorium, having a far shorter life than radium, the time required for the transmutation of half of any amount of this element being only 5.5 years.

Pitchblende, the ore from which radium was first produced, occurs in small quantities in several localities in the United States, notably in Gilpin County, Colorado, but so far this ore has not been the source of any radium produced in this country. Carnotite, a potassium uranyl vanadate, is the ore which occurs most extensively in the United States, the most notable deposits being those of southwestern Colorado and southeastern Utah. High grade carnotite, which is comparatively rare, is a soft talc-like sulfur yellow mineral, corresponding essentially to the composition of a potassium uranyl vanadate. The commercial carnotite ore is a low grade mineral usually found in sand stone formations where the carnotite material acts as a cement for the grains of sand. This low grade ore contains traces up to several per cent. of uranium oxide, the workable ore containing from about 0.5 per cent. upwards. Owing to the greater amounts of lower grade ore, the average working ore contains about one per cent. of uranium oxide, and consequently each ton of this ore contains 2.5 milligrams of radium element. The great problem of radium production is the economical treatment of these lower grade ores, which must be conserved because of their extensive occurrence. The region in which carnotite is mined is remote from railroads, and so the ore must be hauled long distances by burros and wagons. Burros bring the ore from the hills to the wagon roads and the average wagon haul is about forty miles. The ore as found usually consists of a thin layer of sand stone, which crops out on the side of a canyon wall and is recognized by the caracteristic sulphur-yellow color. The narrowness of the seams makes is necessary to take out a large amount of worthless stone to secure the carnotite ore. The seams are usually in the form of pockets so that the value of a claim is dubious until it has been thoroughly explored and worked.

The physical nature of low grade carnotite ore is such as to make possible a mechanical concentration of the values. This is carried out on ore containing 2% or less of uranium oxide. The methods in use are both wet and dry and consist essentially in a process of grinding to loosen the carnotite material from the sand grains and then separating the values from the tails by a process of dry or wet elutriation.

The fine powdered concentrates are next subjected to chemical treatment to remove the uranium and vanadium, and then the residue which still contains the radium is subjected to further chemical treatment to remove this constituent together with the barium salts present in the ore.

Chemically, radium is so nearly like barium as to make it impossible to separate the radium from the barium present in the ore by a single operation. Since a ton of average ore contains only a few milligrams of radium, while the ore usually contains in the order of a half per cent. of barium sulphate or other barium salts, it is obviously simpler to regard the chemical treatment of the ore as a process of removing all the barium from the ore. This is carried out in a number of different ways; some wet, as in the Bureau of Mines nitric acid treatment, which is only applicable to coarsely ground high grade ore, or boiling the concentrates with soda, with subsequent acid leaching; or dry methods such as fusion with alkali or soda, with subsequent solution of the insoluble radium-barium-calcium residue in acid.

The next step in the preparation of radium salts consists in subjecting the radium-barium salt to a process which will separate the radium from the barium. No strictly chemical process for effecting this separation is suitable and practically a process of fractional crystallization of the chloride, bromide or hydroxide is used. It has been found, for example, that radium-barium chloride, when allowed to crystallize from an aqueous solution, gives crystals containing a greater proportion of radium to barium than was contained in the original salt, or the salt left in solution in the mother liquor. Application of this fact in a process of fractional crystalization makes it possible to concentrate the radium in the "heads" and the barium in the "tails", resulting finally after hundreds of operations in the production of a few hundred milligrams of comparatively pure radium salt from the treatment of hundreds of kilos of the crude radium-barium salt as obtained from the ore.

The greatest use for radium at present is in the treatment of various growths, malignant and benign. Certain types of cancer respond readily to the action of the beta and gamma rays of radium (the more penetrating rays) and this same action also enables the medical man to give great relief in certain types of hopeless cancer, where medical science has heretofore been helpless. For these medical purposes the radium salt is used, not as a medicine but rather as a physical agent for the production of its characteristic rays. The radium, usually in the form of radium-barium sulphate, containing from 60% to 90% of pure radium sulphate is either sealed hermetically in tiny thin walled glass tubes or is spread in an enamel or varnish over the surface of a metallic plaque. In this way the radium salt is comparatively safe from loss and may be utilized continually with practically no depreciation, since the activity falls by only 1 per cent. in about twenty-five years.

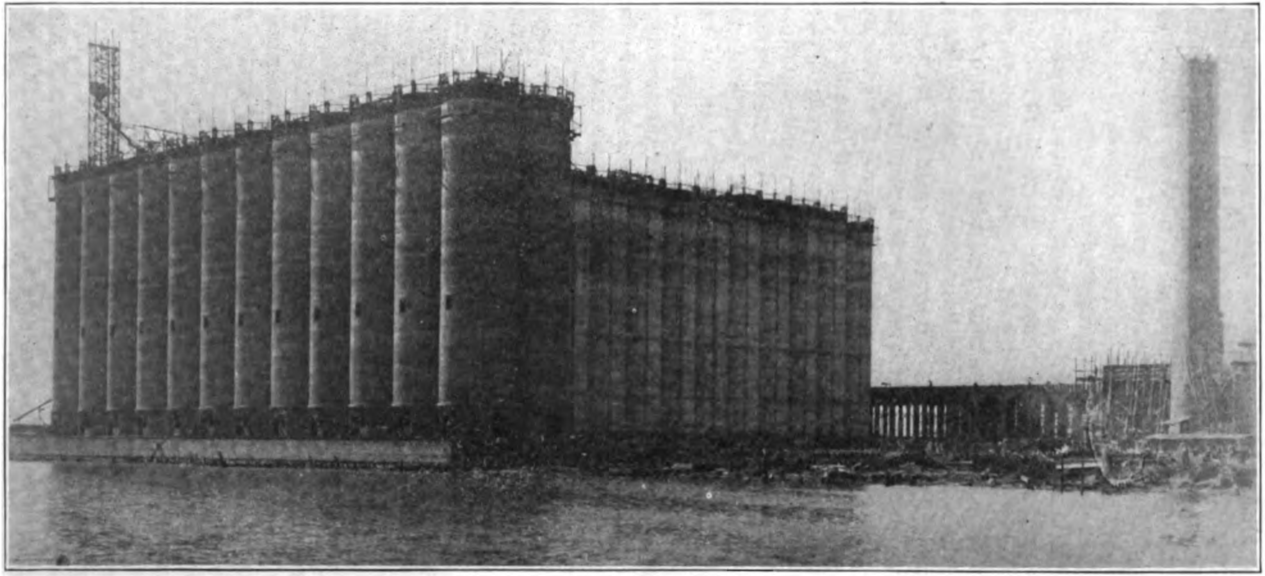
It is of interest to note that the alpha rays from radium are helium atoms, shot out with tremendous velocity from the disintegrating atom, and this helium gas, owing to the low penetrating power of the alpha rays, accumulates in such sealed tubes of radium salt. One gram of radium element produces in a year 163 cubic millimeters of helium gas (normal temperature and pressure), the presence of which can readily be confirmed by suitable spectroscopic tests.

When radium rays play upon certain crystalline substances, such as phosphorescent zinc sulphide, the diamond, willemite, barium-platino-cyanide, kunzite, etc., there is produced a degree of luminosity depending upon the quality of the material used. It has been found, for example, that each alpha ray (helium atom) upon striking a diamond or zinc sulphide (Sidot's hexagonal blende) or willemite causes a single scintillation. This effect is utilized in the preparation of so-called "permanent" luminous compounds or paints. A suitable quality of phosphorescent zinc sulphide is admixed with a small quantity of radium (0.025 to 0.20 milligrams of radium element per gram of compound) and there is produced a powder which glows in the dark and continues to glow, without requiring exposure to light or other source of energy. This zinc compound, which has been found to give the greatest luminescence for a given amount of radium, unfortunately undergoes a slow deterioration which is more rapid the greater the proportion of radium used. Hence these luminous compounds will not be as lasting as the radium. However, suitable compounds are prepared which will be effective for many years. These compounds are mixed with varnish and the resulting paint is now being applied to many objects that are to be rendered visible in the dark. Watch dials and hands, compasses aeroplane instruments for night flying, electric pull chains and push buttons, etc. (keyholes are usually mentioned, too). The use of radium for this material is second only to its use in medicine.

Experiments are under way to determine other commercial uses of radium, and undoubtedly the near future will see a much greater demand for this precious material than exists even now.

There is probably a total of not more than eighty to ninety grams of radium element in all the high grade radium preparations in the whole world. Of this amount twenty grams have been prepared in the Radium Research Laboratory of the Standard Chemical Company during the four years that production has been under way. Other production in the United States, including the radium produced by the United States Bureau of Mines for the National Radium Institute, probably totals ten grams, making the United States the producer, to date, of over a third of the world's radium supply. The present producing capacity of the Standard Chemical Company is 1.5 grams of radium element per month.

The vanadium in carnotite is ultimately marked as ferro-vanadium. Uranium has recently been successfully reduced to a commercial ferro-uranium in the metallurgical department of the Standard Chemical Company. This ferro-uranium has been found to greatly improve the quality of high-speed tool steel, less than a per cent. of uranium making it possible to produce the highest quality of tool steel, even when the tungsten content of the steel is greatly reduced.



Chicago Elevator, C. & N.-W. Ry.

CONSTRUCTION OF GRAIN ELEVATORS.

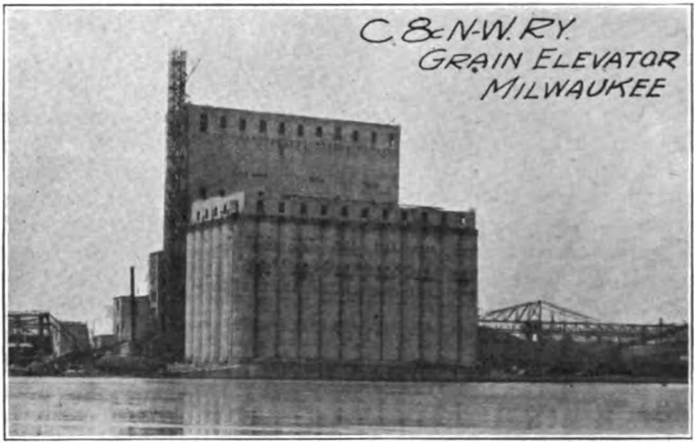
By F. C. Huffman, '05.

On account of the enormous grain business which the Chicago & Northwestern Railway Company is called upon to handle, it has become necessary for the company to enter into the construction of large grain elvators at its important terminals, more especially the terminals which are located on harbors where the grain may be moved in either direction, from water to rail, or vice versa.

In the earlier period it was the practice in building grain elevators to construct them of timber, having the storage bins built of dimension timber, with the smallest dimension in the vertical position, drifted together with broken joints and dove-tail style of joints at all corners, making a very good weather proof storage for grain. This, however, was found to be very dangerous on account of fires originating from various sources and the structure was lined and covered with sheet steel. Later, when the price of structural steel reached a low figure, it was found practical to build grain elevators of steel and it was here we notice the appearance of the circular bin construction, having the bins built of sheet steel similar to stand pipes used in water works systems, but built in clusters, making the design along economical lines, leaving the numerous bins fastened together and using for storage of grain the interspaces between bins, as well as the interior portion of the circular bins. With the remainder of the building constructed of structural steel this made a fireproof structure. Not long after the steel type of construction was introduced the concrete and steel method entered the field and has been so satisfactorily executed that it is becoming almost the universal type of construction of grain elevators at the prsent time.

The Chicago & Northwestern Railway Company has just completed a large grain elevator at Milwaukee, Wisconsin, and has under construction at Chicago, Illinois, the largest grain elevator in the world.

The elevator at Milwaukee is located along the Chicago to Milwaukee main line of the railway, just south of the Kinnickinnic River draw bridge on the Kinnickinnic Bay, which is the inner harbor of Milwaukee off of Lake Michigan. This is an ideal location for an elevator, especially from the navigators view point, as the harbor is very close to the entrance from Lake Michigan and there are no draw bridges to encounter by boats serving the elevator.



The contract for pile foundation was let to the Walsh Construction Company of Davenport, Iowa, in May, 1915, and the driving of 5,000 piling, ranging in length from 60 feet to 65 feet, was completed in August of the same year. These piling are spaced two and one-half feet center to center in both, directions under the main portion of the elevator and storage bins, and each pile is subject to a loading of twenty tons. In selecting the desirable length of piling to be used, several borings were taken which gave a variation of clay below the silt deposited by water. This clay grew harder as the depth increased and at a depth of from 40 feet to 60 feet seemed fair for foundation purposes. Several test piles of different lengths were driven and loaded with 50 tons to 60 tons load, and no material settlement was noted other than the small compression of top of pile due to heavy loading. These test piles gave a bearing power of from 22 tons to 27 tons calculated from the Engineering News formula in connection with the pile driver. The piling, upon which was laid the heavily reinforced concrete slab, built as one unit under the entire structure, were cut off below the water level. The contract for the construction of the superstructure, built entirely of concrete, reinforced with steel, was let to the Barnett & Record Company of Minneapolis, Minnesota, in August, 1915, and the elevator was turned over to operator and received grain September 1st, 1916. There is no claim made for record of time on this work, as very little could be accomplished during the cold winter months and the scarcity of labor greatly hampered the progress of the work.

The building consists of a track shed, 156 feet long by 79 feet wide by 40 feet high, a work-house 167 feet long by 48 feet wide by 190 feet high, and 72 storage bins, each fifteen (15) feet in diameter, making the cluster 181 feet long by 103 feet wide, including width of dock, and 117 feet high, including the belt galleries on top and the basement, which is used for the belt conveyors and other machinery.

The track shed is arranged with four tracks running through it in which twelve cars can be unloaded and six cars loaded simultaneously.

The work-house contains the machinery for receiving and handling the grain and for the distribution of same to the different parts of the building and storage bins, scale hoppers, treating and drying apparatus.

The storage bins are arranged for storage inside the circular bins and also in the interspaces between bins. The row of bins along the dock are arranged with hopper bottoms about two-thirds the distance to the top, the upper portion serving as shipping bins for loading into boats along the dock.

The method used in constructing the building was by sliding forms, the walls all being carried up together and the pouring as nearly continuous as practicable.

The following list will serve to show in general the material and equipment used in the construction:

Piling—5,000 pieces, equaling 300,000 lineal feet.
Concrete, 20,000 cubic yards.
Reinforcing steel—1,549 tons.
Spouting—225 tons.
Belting—8,800 feet.
Structural Steel—420 tons.
Motors—58, ranging from 5 to 150 horse power, totaling 2,145 horse power.
Concrete Dock—1,200 lineal feet.
Trackage—25,000 lineal feet of yard tracks.
Capacity—Handling 50,000,000 bushels annually.

The elevator at Chicago, Illinois, is located on the Calumet River in the vicinity of 123rd Street and Torrence Avenue.

The Calumet River has a channel 200 feet in width at the bottom, 21 feet deep and empties into Lake Michigan about four miles northeast of the elevator site at the South Chicago Harbor.

Several borings were made at the site of the structure, all of which were carried down to solid rock, which was from seventy-two (72) feet to seventy-five (75) feet below the surface of the surrounding ground, which had an elevation of from two (2) feet to four (4) feet above Chicago city datum, the zero of which is at mean water elevation of Lake Michigan. The average formation showed the following:

From top of ground to two (2) feet below—turf; from two feet to twelve feet, quick sand; from twelve feet to thirty-eight feet, blue clay, very hard at bottom; from thirty-eight feet to seventy-three feet, hard pan; from seventy-three feet to seventy-five feet, shell rock; at seventy-five feet, solid rock.

Test piles were driven and after very hard driving it was able to get a penetration of thirty-six feet to the underlying hard pan, but the pile began going to pieces under the hammer at this depth. The pile was then cut off and loaded with a sixty-five (65) ton load. A very slight movement of the gauge showed about one-sixteenth (1/16) inch change, which was due to the fibre change in the timber under the heavy load. It was decided from the investigation that piling ranging from thirty-eight (38) feet to forty (40) feet would be desired. The design of the foundation required the loading of each pile to be two tons per pile. This required the piles to be placed two and one-half (2½) feet center to center in either direction.

The contract for pile foundation was let to the Great Lakes Dredge and Dock Company of Chicago, Illinois, in September, 1915, and the completion of driving, 18,200 piling, was accomplished in May, 1916.

The contract for construction of the superstructure of the power House was let to the Westinghouse, Church, Kerr & Company of New York City on December 18th, 1915. Field work was started in June, 1916, and the work is expected to be completed by March 1st, 1917.

The Power House is a brick structure, 88 feet by 129 feet, with structural steel roof trusses, resting on heavily reinforced concrete base. It has a Custodis brick chimney 207 feet in height, resting on heavily reinforced concrete base 32′x32′; Stirling Boilers of 3,000 horse power are being installed at present and space for an additional installation is provided for. The boilers are equipped with the latest Westinghouse stokers and coal handling machinery. The power installation at present is two 1,500 K. W. and one 500 K. W. turbines. Room is provided for an additional 1,500 K. W. turbine for future use. All power for the grain elevator, as well as for the auxiliary buildings, will be electrically transmitted and the lighting, heating and watering will be furnished from this central plant. Water for the cooling system in connection with the condensing turbines and for the fire protection line is supplied through a thirty-six (36) inch intake and discharge pipe connected with the Calumet River.

On December 31st, 1915, the contract for the construction of the superstructure and equipment of the elevator proper and the remaining auxiliary buildings was awarded to the Witherspoon-Englar Company and Grant Smith & Company of Chicago, Illinois. The field work was started in February, 1916, and was vigorously executed until the extreme cold weather of December of the same year stopped the concreting, which at that time consisted of the building of reinforced curtain walls which could not safely be built without covering and heating plant.

The structures under this firm's contract consist of the following: Grain Elevator proper, which covers a space of ground 563 feet by 287 feet, including a track shed, work-house, storage house, river house, marine tower, dock and shipping gallery. All of these are connected as one unit, and constructed of reinforced concrete and structural steel encased in concrete.

The track shed is a one-story structure 48 feet in height, having five through tracks, each holding six cars for unloading or loading, as required.

The work house consists of 95 circular bins, 15 feet in diameter, surmounted by a cupola, built of structural steel with reinforced concrete curtain walls rising to a total height of 215 feet.

The storage house consists of 182 circular bins, 22½ feet in diameter, of which 104 bins are being constructed at present, the remaining 78 bins to be added in the future. Above the top of the bins are the belt galleries, which makes the total height of the storage house 139 feet.

The river house consists of 24 circular bins 22½ feet in diameter, surmounted by a cupola similar in construction and having to form like functions to those of the workhouse, only instead of handling the grain from and to cars it deals with the moving of grain from and to the boats. The total length of this structure is 194 feet.

The marine tower is located at the south end of the river house and is 153 feet high. It has a marine leg 96 feet long for receiving grain from boats and delivering the grain to the river house for further disposition.

The dock is of reinforced concrete 1,200 feet long and 9 feet above the water, extending along the river front of the river house and adjacent thereto, which will accommodate the unloading of one boat and the loading of another simultaneously, or the loading of two boats at the same time.

The shipping gallery is located on the north side of the river house along the dock, and has for its functions the loading of grain into boats. It is used for trimming the loads into boats while another boat is receiving the bulk of its load from the numerous spouts in front of the river house.

The auxiliary buildings are as follows:

The Welfare Building is a two-story brick structure, 82'x65' furnished with all modern equipment for accommodating employees.

The Office Building is a three-story brick structure, 42 feet by 58 feet and besides serving as office room is equipped with private sleeping rooms and dining room for the officers and operators of the grain elevator.

The Shop Building is a one-story brick building, 82 feet by 32 feet, to be used for housing the equipment for making repairs to the machinery used in the elevator.

All of the above buildings and power house are located north of grain elevator.

The dust house is a one-story brick structure, built on an elevated reinforced foundation, for receiving dust and cleanings from the grain for the purpose of sacking and disposition as a by-product. This building is located south of the work house.

The sulphur storage house is a one-story brick structure, 30'x17', for the storage of sulphur used in treating the grain.

In the construction of the grain elevator proper the method of the sliding forms was used on the circular bins and the stationary boxed-in forms on the remainder of the work. The circular bins were built in three units in the following order: The 104 bins of the storage were built 95 feet in height in about three weeks, working two eleven-hour shifts per day, averaging a little over four feet per day with a record day of approximately 9½ feet. The 24 bins of the river house were built 90 feet high in about eleven days, with a record run of twelve feet in one day. The 95 bins of the work-house were built 90 feet high in about three weeks, encountering two "shut-downs" on account of freezing weather. The progress was somewhat retarded because of cold weather, as it became necessary to cover the green concrete with hay and straw, then remove same and apply hot water to remove any indications of frost, thereby assuring a perfect bond in the concrete when pouring was continued.

The concrete handling plant consisted of three one-yard mixers, each having a daily capacity of 1,200 cubic yards of concrete which was delivered by use of towers and spouting to various parts of the work. The sand and gravel was delivered by belt conveyor from the cars to a large storage hopper, from whence it was delivered by belt conveyor to the smaller individual hoppers at each concrete mixing plant.

On account of the size of this structure it may be interesting to know the amount of material used in the construction and the following is a list of units used:

Excavation, 80,000 cu yds.
Foundation Piling, 18,200 pieces, 698,000 lineal feet.
Concrete, 62,000 cu yds.
Reinforcing steel, 1,750 tons.
Structural steel, 5,400 tons.
Elevating and conveying belting, 52,033 lineal feet (10 miles).
Form lumber, 1,900,000 feet BM.
Cement, 94,000 barrels.

OPERATING FACILITIES

Storage capacity with 182 storage bins	10,000,000	bushels
Storage capacity with 104 storage bins	6,000,000	"
Daily receiving capacity by cars	1,296,000	"
Daily shipping capacity by cars	1,296,000	"
Daily receiving capacity by boat	480,00	"
Daily shipping capacity by boat	1,440,000	"

The entire capacity of the elevator can be turned over in two days time if necessary on account of grain heating.

A Zeleny thermometer system registering the temperature in all the bins at five feet intervals is used, which will indicate the temperature of all grain.

RAILROAD FACILITIES

To serve the grain elevator, 18 miles of yard tracks were constructed connecting with the belt line railway serving this district. The yard tracks are divided into receiving tracks, running tracks, storage tracks and hopper tracks. The hopper tracks are so arranged that cars go through the track shed, depositing or receiving grain, as the case may be, and are taken away by the gravity system of switching. The capacity of these yard tracks is 1,250 cars.

Also in connection with the railroad operation it was necessary to construct a three-stall brick engine house for switch engines, a 50-ton capacity mechanical fuel station and a 47,000-gallon water tank.

Provision has been made for a future double track line to pass between the storage house and river house to serve other industries which will be constructed along the river front.

The entire work of designing and construction of the elevators was made under the direction of W. H. Finley, Chief Engineer of the Chicago & North Western Railway Company. The design of the Milwaukee elevator was made by the Toltz Engineering Company of St. Paul, Minnesota, while the John S. Metcalf Company of Chicago, Illinois, were the designing engineers for the Chicago elevator.

A BRIEF REVIEW OF TWENTY-FIVE BOILER TESTS.

By Prof. Gilbert A. Young.

INTRODUCTION

The past ten years have been remarkable for epoch-making improvements in power plant efficiencies. Strangely enough, greater efficiencies have been effected in the boiler room than in the engine room, for previous to this time engineers were inclined to confine their efforts to increase the performance of the steam engine or turbine with only casual glance in the boiler room. The reason for the proper consideration of this part of a power plant during the past decade is undoubtedly due the gradual increase in the cost of coal and a final realization that greatest economies were to be found in the steam-generating apparatus.

For more than ten years the writer has been associated in a consulting capacity with improvements in power plant performances of the LaFayette Box Board and Paper Company. Twenty-five tests have been run on the boilers of this interesting plant, many of which were in the nature of thesis work.

BOILERS AND NEW APPARATUS

The boiler plant consisted, when first installed in 1904, of four Sterling boilers rated at 300 H. P. each, Roney stokers and a good chimney capable of producing a sufficient draft. Since 104 the following changes have been ficient draft. Since 1904 the following changes have been made, all looking toward greater economy.

1905. All boilers' setting and breeching covered with three inches of insulating material and protected by outside metal casing of heavy sheet iron.

1908. McDonough system of automatically regulating boiler feed pumps, steam prussure, draft and stoker engine.

1910. Recording instruments for all pressures, drafts and temperature connected with boilers.

1911. Installed Indicating-Recording Venturi meter on feed water and Uhrling's indicating and recording carbon dioxide instrument.

1913. Green economizer with fan on the flue gases automatically controlled by McDonough system.

1916. Smoke and draft recording instruments.

OUTLINE OF TESTS

A brief outline of the tests conducted giving date and general conditions may be seen in Table 1. The length of tests varied from eight to twenty-four hours. Coal and ashes were weighed and the water weighed or sent through

OUTLINE OF TESTS ON BOILERS. TABLE 1

No.	Date	Nature of Tests	Men Involved	No. of Boilers	Conditions
1	Mar., 1906	Thesis	Hammerstadt and Berry	4	Twenty-fours Normal Conditions
2	Jan., 1907	Thesis	Pape and Griest	4	Twenty-fours Normal Conditions
3	Feb., 1908	Thesis	Schumaker, Scipio, Shafer, Thale, Babcock	3	Twenty-fours Normal Conditions
4A	July, 1908	Acceptance Test	G. A. Young	3	Before installing McDonough Automatic Regulators
4B	Aug., 1908	Acceptance Test	G. A. Young	3	After installing McDonough Automatic Regulators
5	Feb., 1909	Thesis	Himmilright and Reese	4	Twenty-four hours Normal Conditions
6	Feb., 1910	Thesis	Eggman, Speck, Templin	4	Twenty-four hours Normal Conditions
7	June, 1911	Acceptance Test	G. A. Young	4	After installing Smokeless Furnaces
8A	Dec. 21, 1911	Thesis	Stockton and Abbott	4	Attempt made to vary amount of Carbon Dioxide by regulation of Dampers, Draft and Ash Pit Doors
8B	Dec. 22, 1911	Thesis	Stockton and Abbott	4	
8C	Dec. 23, 1911	Thesis	Stockton and Abbott	4	
8D	Jan. 13, 1912	Thesis	Stockton and Abbott	4	
9A	May 14, 1913	Acceptance Test	G. A. Young	4	Without Economizer
9B	May 15, 1913	Acceptance Test	G. A. Young	4	With Economizer
9C	May 16, 1913	Acceptance Test	G. A. Young	3	With Economizer
10A	Feb. 12, 1914	Thesis	Parish	4	With Economizer
10B	Feb. 13, 1914	Thesis	Parish	4	Without Economizer
11A	June 29, 1916	Comparative Coal	G. A. Young	3	Old Vincennes Coal. With Economizer
11B	June 30, 1916	Comparative Coal	G. A. Young	3	Old Vincennes Coal. With Economizer
11A'	June 29, 1916	Comparative Coal	G. A. Young	3	Old Vincennes Coal. Without Economizer
11B'	June 30, 1916	Comparative Coal	G. A. Young	3	Old Vincennes Coal. Without Economizer
11C	June 28, 1916	Comparative Coal	G. A. Young	3	Vandalia Coal. With Economizer
11D	July 1, 1916	Comparative Coal	G. A. Young	3	Vandalia Coal. With Economizer
11C'	June 28, 1916	Comparative Coal	G. A. Young	3	Vandalia Coal. Without Economizer
11D'	July 1, 1916	Comparative Coal	G. A. Young	3	Vandalia Coal. Without Economizer

a Venturi meter which could be calibrated by weighing the water. All gauge and thermometers were calibrated before and after tests and all conditions as suggested by the American Society of Mechanical Engineers' Code of Testing were observed.

DISCUSSION OF GRAPHICAL RESULTS

A copy of the significant results of each test outlined above may be found in Plate 14. From the results thus tabulated a number of interesting curves have been drawn. No elaborate discussion will be made of the results graphically shown in Plates 11, 12, and 13, but a few outstanding points will be emphasized.

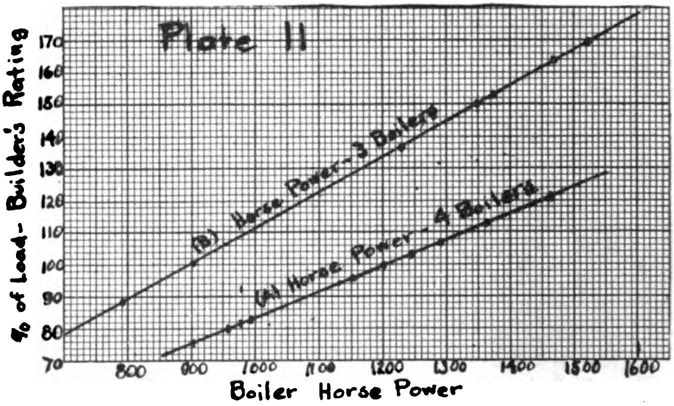


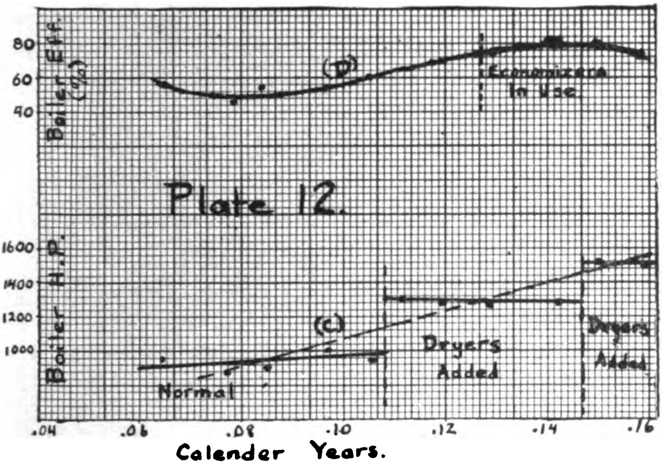
PLATE 11.

Curves A and B. These curves show the range of load on the boilers with three and four units in service. Each curve is interesting only as it shows with four boilers (Curve A) the load, in percent of builder's rating, increased from 70% to 123%. With three boilers the range of load increased from 88% to 168% of builder's rating, while with either three or four boilers in service the boiler horse power developed increased from 800 to over 1,500 during the period of ten years, which the tests cover.

PLATE 12

On this plate the boiler power and boiler efficiency for each year have been averaged and plotted covering the ten years from 1906 to 1916.

Curve C. This curve shows the yearly increase of boiler horse power. It is drawn by passing a line through the average of each of the three groups which are made



by increasing the output in paper tonnage made possible by the installation of additional dryers.

Curve D. This boiler efficiency curve is a record that any power plant manager can be proud of and only a few can boast of in truth. It portrays a great story. With an efficiency during the first two years averaging less than 50% it has been increased so that the average of the last three years is over 75%. This is a *fifty percent* increase of boiler efficiency in a period of less than six years.

It is interesting to note the three installations which to the mind of the undersigned have brought this about:

(a) 1908. McDonough automatic regulators.
(b) 1910. CO_2 recorders.
(c) 1912. Economizers.

Another very important fact may be learned from a study of this efficiency curve, namely: The *limit of increase of boiler efficiency has been passed with three boilers in service.* This is shown on curve F on Plate 13, also. It will be noticed that in the recent tests the three boilers were carrying 163% of the rated capacity.

It can be prophesized, with every chance of fulfillment, that by the use of the smoke and draft recorders at his service, Mr. Miller will be able to increase the present boiler pressure, but that *this increase could be realized to a greater extent by the use of four boilers.* With the present load the four boilers could carry at 110% to 120% of their rated capacity, and this is the *over-load* capacity carried during the years 1914 and 1915, when the boiler efficiency was averaging 76%.

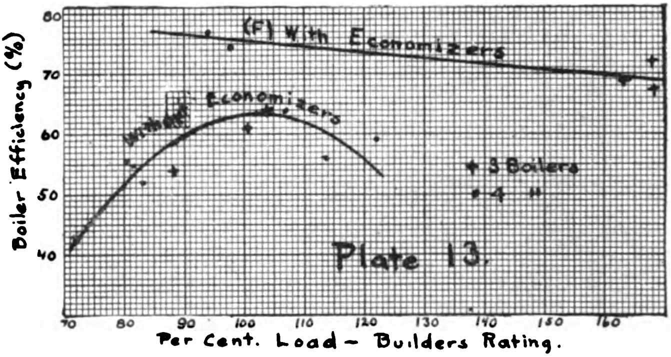


PLATE 13.

The curves on this plate are also very interesting and instructive. The relative boiler efficiency with and without the use of the economizers is shown at a glance. It is also evident that these efficiencies decrease as the precent of over-load increases, but not so rapidly when the economizers are used. The results of the tests shown in Group A can not be considered as a part of Curve F, because they were run by artificially decreasing the per cent of CO_2.

CONCLUSION

A lengthy summation of the conclusions is not necessary because so many interesting facts may be seen from the curves just discussed. A few, however, may not be amiss:

(a) During the past ten years the horse power of boilers has increased from 800 to over 1,500.

(b) During the same time the boiler efficiency of the plant has increased from less than 50% to over 75%, which is 50% increase.

(c) This increase of 50% is due to four factors:—

1. McDonough automatic regulators.
2. CO_2 records.
3. Economizers.
4. Increased personal interest and pride in boiler room economics due to the recording instruments which place a record of their achievements on the president's desk each day.

(d) A very decided increase of economy is effected by the use of the economizers and this increase is true whether three or four boilers are in service.

(e) The limit of increased efficiency has been passed with three boilers in operation.

(f) A satisfactory increase in economy could be expected by carrying the pressure load on four boilers.

(g) Some increase in efficiency may be expected with certainty even with three boilers by use of smoke and draft indicators under intelligent and careful supervision.

The story of the achievement of this plant would not be complete without stating that the plant was originally built for an output of fifty tons of boxboard in a day of twenty-four hours. It is now averaging *one hundred and ten tons.* The coal per ton of board on day of first boiler test was two and nine-tenths, while today a ton of boxboard is produced on *less than three-quarters* of a ton of coal

FLYWHEEL TYPE MAGNITO.

By H. W. Asire, '14.

Although a comparatively recent development, the Flywheel type magneto has found favor both with the engine manufacturer and the user. While commonly known as the Flywheel magneto it does not always serve as a flywheel, as its weight is often insufficient for this purpose, in which case it must be attached to the cast iron flywheel. Not only is weight a deciding factor, but it is often more convenient to moumt the magneto upon some auxiliary shaft such as the cam or pump shaft on certain of the heavier engines.

The magneto treated in the following discussion is strictly of the high-tension, self-contained type and must not be confused with generators built into the flywheel that supply current to induction coils for ignition purposes.

The outboard or detachable rowboat motor was probably the first to use the flywheel type extensively. Here the magneto serves both as the flywheel and a source of ignition for the motor. One of the first types to be used for this purpose was modeled after the conventional magneto and in principle they are the same. Fig. I shows only the principal parts. Circular magnets (M) mounted in a non-magnetic dome of brass or aluminum serves as the flywheel. These magnets are placed with like poles together forcing the flux through pole pieces P, which are also attached to the dome, through the air gap to the armature A. The armature is wound in the conventional manner with primary and secondary. The armature is stationary, i. e., it does not revolve, but is adjustable for timing purposes. The magnets revolving past the armature cause a flux change through the armature setting up currents in

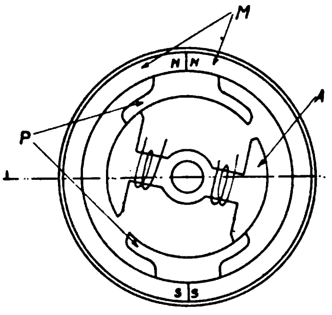


Fig. 1

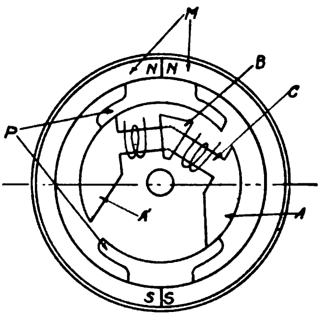


Fig. 2

the windings in the usual manner. The primary circuit is broken by means of a breaker equipped with contact points.

In this type of construction the flywheel is keyed to the crank shaft and revolves at engine speed. The crank shaft projects through the armature plate and laminations. Recent developments have brought out an armature construction that affords greater winding space and eliminates the necessity of the shaft passing through the armature core—an objectionable feature inasmuch as the cam which operates the breaker is mounted upon this shaft. This construction is illustrated in Fig. 2. AA′ are the armature wings and B is an insulating block separating the two windings.

For several years the magneto described in the foregoing was produced without competition, but the evident demand for this type of ignition induced another company to bring out a flywheel type. This magneto, placed on the market in 1914, was a radical departure, both in construction and principle of operation from all previous magneto types. This construction described in the following is employed at the present time by the Quick Action Ignition Company of South Bend, Indiana. The rotating element consists of the dome containing one circular magnet M (Fig. 3), with short polar gap and inwardly projecting pole pieces PP. The armature plate or stationary element supports the armature laminations (A) upon which the coil is placed. The core is constructed in two parts to make possible the assembly of the complete coil in place upon the laminations. In this construction a spark occurs whenever the armature spans the polar gap. The action proceeds as follows: Assume that the magnet is rotating and has reached the point where the armature wing A just spans the magnet gap. At this point the flux is passing through

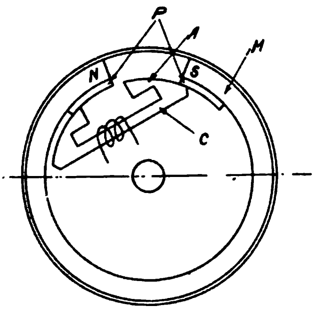


FIG 3

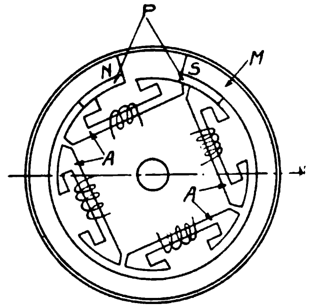


FIG 4

the wing and the flux through the core is zero. Further motion of the magnet shifts the path of the flux from its shunted path to one through the core. During this period the primary winding has been short circuited and the current has built up to a maximum value. At the peak of the wave the breaker opens the primary circuit, allowing the flux to suddenly build from zero to a maximum in the core, linking in this manner with the secondary turn and producing the spark. The breaker is operated by means of a fibre cam projecting from the hub of the flywheel in such a position as to open the contact points of the breaker and open the primary circuit at the instant when the leading pole shoe has separated from the leading armature wing by about one-quarter inch. The condenser is shunted across the contact points of the breaker in the usual manner to reduce sparking.

With this type of magneto it is possible to place any number of these coil units on the armature plate, limited only by the available space in order to fire multi-cylinder engines, each coil providing a spark for one cylinder except in the case described later. Every unit complete for firing one cylinder is composed of a Coil, Condenser and Breaker. In this manner the firing of one cylinder is independent of all others and if a coil, breaker or condenser fails it means that only one cylinder becomes inoperative. The magnet in this connection is disregarded, as the chance of failure from this cause is very remote.

Figure 4 illustrates the construction just described. A single magnet encircling all of the coils provides the source of energy for all coils. One cam located upon the flywheel hub serves to operate the breakers successively at the proper instant. The absence of distributers, collector rings, brushes and bearings, inherent in the ordinary magneto, eliminates a great source of trouble.

One innovation in magneto design that may be worthy of mention is the employment of the open magnetic circuit. For years the idea has been drilled into the magneto user that magnets should at all times be supplied with a keeper to conserve their flux supply, and, indeed, this to a certain extent is true with the conventional type magneto employing more than one magnet. In this case, if the keeper were removed (for this purpose the armature serves), one magnet would demagnetize the other to a limited degree. With the type of construction presented by the flywheel megneto employing one circular magnet, however, the magnet stands as a unit far removed from any demagnetizing influences. The use of a magnet of nearly twice the length of the magnet found in the conventional magneto nearly doubles its permanence as a further factor of safety, and if further proof of its stability were needed the fact remains that magnets in service for over four years and under constant observation have failed to show any drop in magnetic strength. By this it is not meant that the magnet has the value found immediately after charging. This value is not stable, but decreases somewhat after ageing and assumes a stable condition below which value the strength of the magnet will not drop in actual service.

There are perhaps four leading fields open at present to the flywheel type magneto, where the advantages of this type are peculiar. On the Motorcycle, Tractor, Aeroplane and Marine engines there seems to be a very decided field for this type of ignition. On the outboard motor it has proved almost indispensable, although battery ignition is still supplied in some cases.

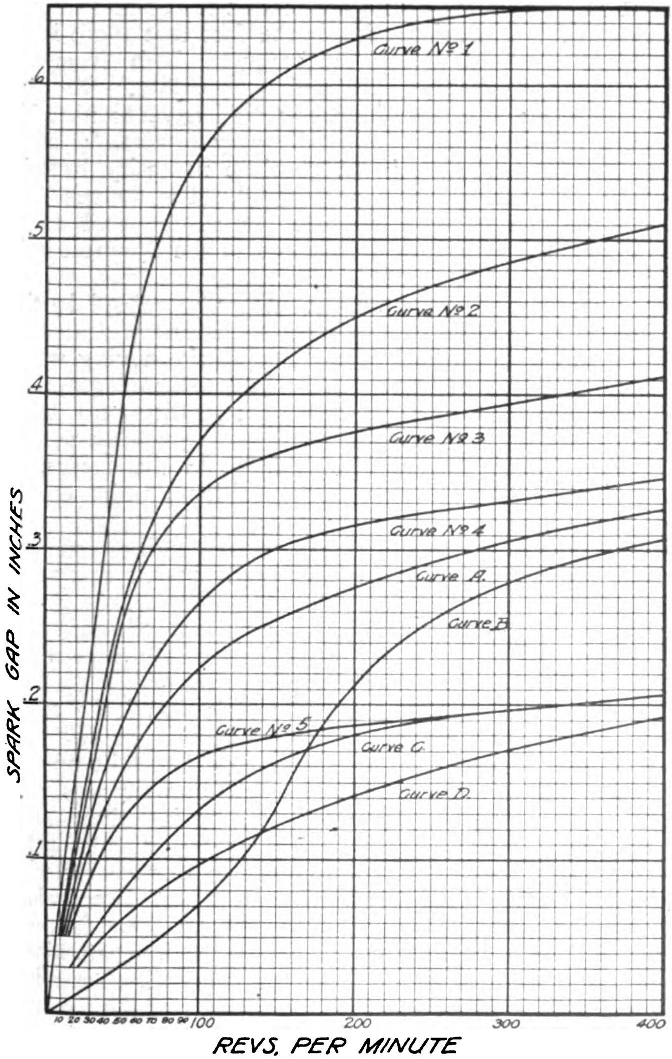
The magneto is now beginning to make its appearance upon the lightweight motorcycle and motor wheels. The saving effected by utilizing the magneto for a flywheel is considerable and offers a great improvement in the general appearance of the machine. Gears, gear housing and brackets mounting the ordinary magneto are eliminated. Where the flywheel is mounted inside of the crank case and the magnet must likewise be mounted within this space, the problem is more complicated. The magneto becomes not only inaccessible, but the quantities of dirty oil present make such an installation practically impossible Even if these difficulties were overcome, the magnetic losses to the iron crank case would be excessive unless the crank case were made prohibitively large. However, in spite of the drawbacks encountered in the motorcycle field, the number of machines having external flywheels soon will be far in excess of those having the enclosed construction.

The use of this type magneto on the tractor presents a problem not encountered in the foregoing. Here the magneto must be mounted in such a position as to make it accessible and at the same time provide a certain degree of protection. While the magneto is in no sense delicate, the service encountered in the ordinary farm tractor is so severe as to require extreme strength. As some one expressed it, "Strong enough so that you can hit it with a hammer and break the hammer". On the tractor it is sometimes necessary to resort to an auxiliary shaft for mounting the magneto, as the crank shaft is so large and the flywheel so heavy that it becomes necessary to abandon this part as a magneto location. Up to this time the flywheel magneto has not been used extensively for tractors, but it offers peculiar advantage for this type of machine. The heavy tractor employs a low speed engine so heavy that the cranking speed in some cases is not over twenty-five or thirty R. P. M. The ordinary magneto must resort to spring starters known as impulse starters to produce a sufficiently strong spark at these speeds for ignition. Here the flywheel type is used to advantage as its spark at cranking speed is nearly as great as at operating speeds. This characteristic is produced by its larger diameter and its peculiar coil construction which makes possible the spark curve shown in Figure 5. The simplicity of construction used in the flywheel type, together with its ruggedness, affords advantages that cannot long be ignored in tractor construction. In some instances the magneto can be mounted within the cast iron flywheel dished out to receive it. Non-magnetic spacers provide the required clearance of about one inch between the magnet and the cast iron. These spacers also center the magnet within the flywheel.

The distinct advantages for Aeroplane service must not be overlooked. Here reliability is the first consideration. With the present magneto ignition of the conventional type, generally two complete magnetos are employed, sparking two independent sets of spark plugs. If one magneto fails the other machine continues to operate the engine. With the flywheel type, where a firing unit consists of a coil, condenser and breaker, the failure of any one of these parts means the failure of only one cylinder. Although the permanent magnet is common to all units, the chance of its failure is so small as to be negligible. With this type of ignition, there is no problem of distributing the spark to the cylinders. The coil units are placed in such position relative to the cylinders as to cause the spark to occur at proper instant. For the revolving cylinder type engine the armature plate mounting the coils is revolved in place of the magnet, eliminating the necessity for distributers even in this case.

Upon first thought it would appear that the cost of such construction would be prohibitive with the use of so many coil and breaker units, but contrary to this idea the machine can be produced very cheaply. This is made possible by the fact that the available space is not limited as in the ordinary magneto and the workmanship need not be so precise. The very nature of the machine precludes the possibility of employing small and delicate parts.

Repeatedly the question is asked why the flywheel type is not applied to the automobile. Obviously the advantages



Sparking distances at speeds from 0 to 400 R.P.M. Curves 1,2,3,4,5 show characteristics of Type F.J. Magneto;-A,B,C,D are from rotating armature Types.

Fig. 5.

of this type would be considerable, but several other important factors enter into its application to the automobile. Perhaps the first consideration is the fact that there is no convenient place to mount the magneto, both from the standpoint of available space and accessibility. To provide such space the manufacturer would have to alter his design, a change that is necessarily very reluctantly made unless the improvement is an absolute necessity brought about either by competition or demand. The conventional magneto on the automobile gives fair results and unless something unusual occurs the change to the flywheel ignition will not be made for some time to come.

To summarize then, the advantages presented by the flywheel type over the conventional magneto are somewhat as follows: The flywheel type employes no moving wires, brushes, collectors or distributers; has no bearings of its own, but utilizes the engine bearings; requires no belts, friction pulleys, gears, trips or brackets; provides a system easily timed once the magneto is fitted to the engine, as the flywheel is keyed in a given position on the engine shaft; increases the operating factor of safety by providing separate units for each cylinder; provides ignition with an unlimited timing range, giving an equally good spark at all settings; provides a spark at cranking speeds that is nearly as great as at operating speeds. The amount of space that can be devoted to the armature and its windings is much greater than other magnetos afford. This makes possible a very rugged coil construction that resists electrical strains, water and hard usage. In cases where the Type "F" acts as the engine flywheel it can hardly be said to take up any room, since it displaces a part for which room was provided. It must not be assumed that the introduction of the flywheel magneto has been over a rose-strewn path. Many early failures were encountered and overcome with much difficulty and in a great many cases prejudice against this type magneto has been encountered by these failures. The costly mistakes made in some of the first machines, however, were structural and not fundamental. Later improvements have overcome all these faults and the flywheel type is gradually coming into its own.

RATES FOR ELECTRIC LIGHTING AND POWER

By E. G. RALSTON, '13.

Electric energy is a manufactured comodity. Like the majority of commodities it is manufactured from certain raw materials, and is usually sold and distributed to a number of consumers residing over a certain territory. The sale of this product cannot be accomplished in the same way as with others, however, because its cost of manufacture and distribution varies greatly with certain well known quantities. There is no efficient or practical way in which a large amount of electrical energy can be stored for commercial purposes as is the case with practically all other articles. Hence an electric plant and distribution system must be large enough to meet the maximum load of the system. In other words Central Stations must manufacture and deliver their product at the same instant it is needed by the consumer.

In fact, it is now generally recognized that there are three items of expense to be considered in rate making, namely:

(1st). THE CAPACITY EXPENSE.—This expense is the interest on the cost of the apparatus necessary to carry the customer's maximum load. This investment must cover the cost of the part of the Central Station equipment allotted to each customer, a portion of the transmission line to which he is connected, and of the transformers or sub-stations supplying him, a certain fraction of the real estate, buildings, etc., a certain portion of the general expense and taxes and depreciation on this investment, or in other words it could be classed as a rental charge for the equipment necessary to take care of a customer's maximum load.

(2d). OUTPUT COST.—This is the cost of the electric energy used by the customer. It consists of the cost of the fuel, oil, water and incidental power-house supplies used in generating the energy which he uses plus the pro-rated labor cost of operation.

(3d). THE CONSUMER'S EXPENSE.—This is the expense of reading the meters, making out and collecting the bill, new business expense and customer's premises expense. The cost of fuel, the cost of labor, the average distance of distribution of energy from the Central Station, the power factor and the diversity factors of the customers all effect or in fact actually determine the numerical value of these items.

In considering present day rates, we may as well begin by admitting that there is no system to-day that is satisfactory to all parties concerned. The public as a general rule desires a block rate applying to all classes of consumers, i e., a certain rate per kw. h. for the first unit of kw. hours consumed per month, a certain lower rate per kw. hour for the next unit of kw. hours consumed per month, etc. They cannot see why there should be any distinction made between power loads and residence lighting loads or between residence lighting loads and electric cooking rates, since the energy is delivered over the same wire and generated by the same apparatus. They also seem to feel that if a certain factor is given as an example a 2½c rate and the residence customers of the same company are charged a 10c rate, that they are being robbed in order that the factory may enjoy a discriminating price. Progressive Central Stations on the other hand desire a schedule that fulfills as nearly as possible the requirements outlined below. The block system of rate can not be condemned too strongly. It tends to reduce rather than increase a Central Station's sales or output. Thus a block rate must necessarily be based on the average output cost of a Central Station. The average cost of production per kw. h. for ordinary Central Station is so high that large factories would install their own plants before they would pay a rate based upon average costs. Thus, a Central Station would soon find itself supplying only residences and small commercial users, thereby creating poor load factors and higher rates to its remaining consumers.

Any rate schedule should have four primary objects, namely:

(1). To secure a satisfactory profit for the company.

(2.) To develop the sale of the Central Station's product. (a) By discouraging the use of private plants or other sources of light and power. (b) By developing new uses for electrical energy, such as electric cooking, electric refrigeration, electric furnaces, electric ovens, etc.

(3). To improve the load factor of the system. (a) By improving the load factor of individual customers. (b) By improving the diversity factor of the customers.

(4). To prevent discrimination by compelling each class of customers to bear their share of the Central Station cost.

It is evident that any schedule which even attempts to accomplish the above four requirements must consider not only the kilowatt hours used by different customers, but also their maximum electric loads and the time of their occurrence with respect to the time of the peak of the Central Station system.

The class of rates fulfilling these requirements most completely are known as Demand and Energy Rates. This method of selling energy, introduced by Hobkinson in England about twenty-five years ago, consists of a certain fixed charge per month per kw. of maximum load, known as the Demand charge, and a low rate for the energy actually consumed, which was called the Energy charge. The Demand charges represented all the fixed costs to the utility for supplying customers. For example, if a given customer had a 10 kw. load during peak hours, the utility would have to have 10 kw. of apparatus in its station, lines and transformers for this particular consumer. The Demand charge might be termed a Rental charge for this equipment, and would be independent of the number of hours a day this customer used his load. The Energy charge represented the cost of the energy actually used by the customer.

It can be seen from the following example that as a customer's load factor is improved, his rate is automatically reduced by the above schedule. Suppose a customer is being billed upon a Demand and Energy contract which calls for $2.00 per month per kw. of maximum load of 2c per kw. h. for the energy he actually uses. Suppose that this customer is operating a small factory with only a day shift working. Under these conditions suppose the maximum load required to pull his machines is 10 kw. or 13 1/3 h. p., and the watt hour meter registers 2000 kw. hrs. per month. His bill then would be $2×10=$20.00 for his demand charge, plus 2c×2000 or $40.00, his energy charge, or a total of $60.00. This is equivalent to a 3c rate. Now suppose he puts on a night shift just equal to his day shift. His consumption would then be doubled or 4000 kw. hrs. per month. His maximum load would be the some, however, or 10 kw. Hence his total bill for the month would be the same demand charge of $20.00 plus an energy charge of (2c×4000 or $80.00) or $100.00. This is equivalent to a 2½c rate, or a reduction of ½c per kw. h. On the other hand if instead of increasing his output by adding a night shift he had doubled his day shift, he would have increased both his maximum load and his consumption and thus would not have earned a better rate. Hence it is seen that customers operating under the above schedule are encouraged to keep their maximum electric load or demand as low as possible, or in other words they are encouraged to improve their load factor. This, of course, tends to improve the load factor of the utilities electric system.

In computing the proper demand rate we must consider three main factors, namely, (1) the cost of the utilities apparatus at the customer's premises; (2) the pro-rated cost of the transmission line, and (3) the prorated cost of the generating apparatus. The first and part of the second investments will not be affected by the time of day or season of the year of a customer's maximum load. However, the investment in the generating station is largely determined by this item. Practically all stations have certain hours at certain seasons during which their electric load is much greater than at any other time. These loads are known as the peak loads and determine the necessary size of the plant. In this State these peaks usually occur during the late afternoon hours in the winter months, due to the factory, store and residence lighting loads all overlapping. It is evident that a customer whose load is small during these hours should not be required to pay as great a demand as a customer whose greater demand occurs at this time. This fact has brought about the use of the so-called "off peak" schedule. These rates allow a customer a certain rebate on his demand charge calculated on that portion of the demand that is not used during the peak hours.

That practically all companies recognize the demand and energy feature in rate making is shown by a review of schedules in use to-day. Thus a schedule containing rates based upon the kilowatt consumption only and specifying a high residence rate; a medium commercial lighting rate and a low power rate is a recognition of this feature because a residence will show a shorter daily hour use of the maximum demand with a maximum load coinciding with the station peak than most any other class of consumers, while most power loads will be at the opposite extreme. Even very small companies almost always adopt this practice. Moreover, some large companies maintain that the class system, namely, the charging of a certain rate for each class of consumers constitutes the best way for a central station to dispose of its product. While on the average this system may in some cases be correct, it may be considerably at error when applied to many particular customers.

It is better to determine the demand of each customer whose consumption justifies the expense by means of a permanent maximum demand meter connected to his load. There are several satisfactory types of these meters on the market to-day.

There are almost as many forms of Demand Rates as there are companies using them. However, the objects of all are the same, namely, to determine the charges for service to a customer in the same way as it would be determined if he were supplying his own energy by means of a private plant. If this is accomplished satisfactorily, the four objects mentioned above will be achieved in practically all cases where Demand Rates are used. The exact form of Demand Schedules best suited to accomplish this is an open question. There are many factors to be considered besides the amount of the demand and energy charges. If these factors are not determined correctly the demand system will fail either through its failure to produce the correct amount of revenue or through the objections of the public to it.

One of the fundamental and most important requirements of any schedule is the ability of the Central Station to determine accurately the factors that govern the rates specified in the schedule. A schedule should be drawn so that the necessary data on a particular customer's load can be obtained by some practical process at a cost representing a reasonable percent of the customer's monthly bill. A schedule which does not fulfill this requirement will be a troublemaker for all concerned. Thus a demand and energy schedule applying to residence and simply specifying a demand rate of a certain amount with certain off peak clauses regarding the use of small motors, electric irons, etc. and a certain kilowatt hour rate would be worse than useless because there is no way for a central station to determine these factors accurately in a given case at anything like a reasonable percent of the customer's monthly bill. Hence this kind of a schedule would only result in some customers obeying it and most others violating its provisions, thus fostering discrimination and breeding discontent among all concerned. The same principle applies, although perhaps not quite so apparently to other classes of consumers such as small stores, small power connections, etc. On the other hand a schedule like the above when applied to large consumers might be very satisfactory, the amount of the monthly bill being sufficiently large to justify the cost of determining the necessary factors.

Hence it is evident that if a demand schedule is used, it should be protected by a minimum charge clause, of a sufficient amount to at least cover the cost of determining accurately the necessary billing information. Moreover, it is evident that a demand rate is not desirable or cannot be applied satisfactorily to all classes of consumers. Hence it is necessary to supplement any demand rates a company may have by certain optional rates, which are usually lower than the demand rate for small customers. These usually take the form of a residence rate and an optional power energy rate. The demand question is usually taken into consideration in these rates indirectly. Thus, the active room schedule is used for residences because the maximum demand of the residences more or less determines the net rate. The optional power rates usually carry a minimum charge based upon the connected load. Special rates for the development of some new uses for electric energy are also sometimes desirable. The various electric cooking rates now being experimented with, by various central stations are examples of this. There is no scientific reason from a cost standpoint for a central station having these schedules if it has a proper demand schedule. However, they are necessary for the development of certain classes of business. Their use is justified upon the ground that a central station's production cost is lowered as the output is increased, and the load factor is improved, thereby enabling all its consumers to ultimately enjoy a lower rate.

One of the greatest disadvantages of Demand Rates is the objection of the public to them. The words, "demand charge", seem to have an irritating effect upon customers when mentioned in connection with electric rates. Some of this is no doubt due simply to the nature of the words. Moreover the word "demand" does not have any meaning to the average consumer when used in connection with electric rates, nor does he seem to be able to comprehend the nature or theory of the demand charge.

Most customers cannot understand why they should pay more for current used at certain hours of the day than at other times or why they should pay a high demand charge some month when they have actually used only a small amount of energy. They do not realize that practically all their other purchases are made upon exactly the same plan. Thus a manufacturer whose output for a given month was below normal would not think of asking his landlord to reduce his rent for that month. Yet he will register a vigorous kick when he receives a power or light bill containing the usual demand charge, notwithstanding that the two propositions are identical, namely, the rent represents interest, depreciation and profit upon the buildings and the demand charges represent interest, depreciation and profit upon the central station electrical equipment.

It might be noted in conclusion that at the present date electric energy supplied by public service corporations is the only important commodity whose selling price is constantly being lowered. This fact can be largely attributed to scientific rate making which is responsible for the improved load factors of electric systems today. The greatest opportunity in the future for greater returns to electric utility stockholders, lower rates to the public, and the universal application of electric energy for all purposes for which it is suited lies in the art of Rate Making. If satisfactory Demand schedules can be devised and be put in actual use the above opportunity is sure of accomplishment.

INCREASING THE UTILITY OF EXISTING LOCOMOTIVES.

By E. S. PEARCE, '13.

It is the problem of the present day railroad executives to produce at a decreasing cost, against a steady increase in material and labor expense, a greater number of ton miles per hour. This statement applies to freight service for the reason of its being the greatest source of revenue. A comparison between the two principal classes of service for roads having an operating income of $100,000 or more show the following:—

AVERAGE REVENUE PER MILE OF MAIN TRACK

	1905	1915
Freight	$6,147	$6,998
Passenger	1,996	2,200

Roughly, the freight revenue is three times greater than the passenger revenue on an average for all railroads in the United States.

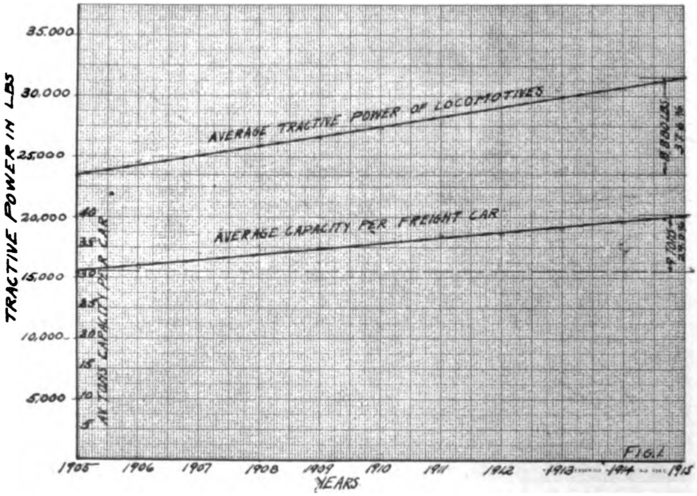


Fig. 1.

Increasing the number of ton miles per hour has been accomplished by enlarging the carrying capacity to the cars; and, by more efficient operation, the number of miles per day per car. This has of a necessity led to greater demand for larger locomotives. The extent and rate at which the carrying capacity of freight cars and the pulling power of locomotives has increased during the last ten

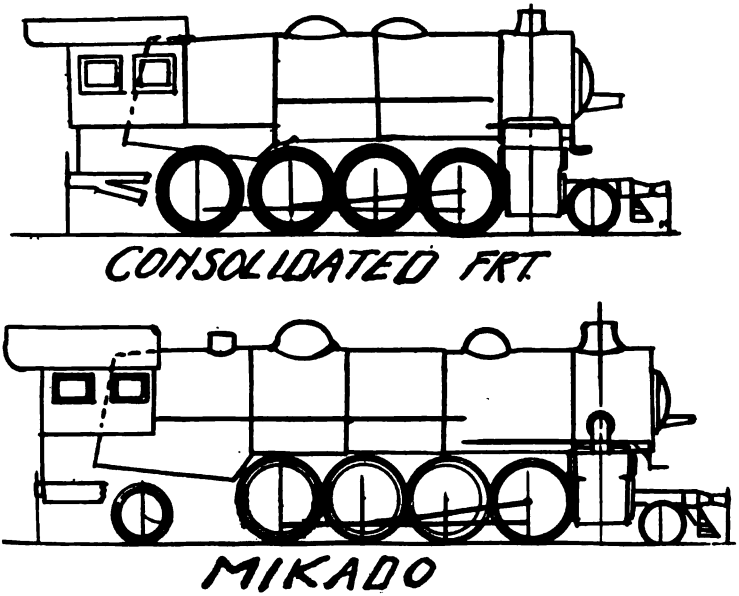


Fig. 2.

Consolidated Frt.	**SPECIFICATION**	**Mikado**
220,000	Total Wt. Engine	281,600
200,000	Wt. on Drivers	213,500
47,000	Tractive Effort	48,600
4.25	Factor of Adhesion	4.38
23x32 in.	Size Cylinders	25x32 in.
200	Boiler Press.	180 lbs.
210	Heating Surface F. Box	230 sq. ft.
3480.6	Heating Surface Flues	3864 sq. ft.
446—2 in.	No. and Size Flues	265—2 ft.
——	Heating Surface Sup. Heat	870 sq. ft.
3700.6	* Heating Surface Equivalent	5399 sq. ft.
108	Fire Box Length	108 in.
75¼	Fire Box Width	75¼ in.
56½	Fire Box Area (Grate)	56½ sq. ft.
Stephenson	Valve Gear	Walschaerts
14 in. Piston	Size and Type Valve	14 in. Piston
63 in.	Dia. Drivers	63 in.
Hand	Reverse Gear	Hand
4.25	Wt. on Drivers÷Tractive Effort	4.38
787	T. E.×Dia. Drivers÷Equiv. H. S.	568
65.6	Equiv. H. S.÷Grate Area	95.5
5.67	Fire Box H. S.÷Equiv. H. S. %	4.26
59.5	Total Wt.÷Equiv H. S.	52
15.78	Vol. Both Cyls.	18.3 cu. ft.
234	Equiv, H. S.÷Vol. Cyls.	295
3.58	Grate Area÷Vol. Cyls.	3.08

* Super H. S.×1.5+Evap. Surface

years is best shown by Fig. 1. Against an average rise of 29% in the carrying capacity of freight cars there has been a rise of 37% in the pulling capacity of locomotives. In view of these facts it is evident that obsolescence must be the controlling factor in the retirement of existing power built ten to fifteen years ago and still in good condition for the service for which it was designed.

Considerable attention has been paid to the question of modernizing existing power by the railroads for the following reasons:

First—The high retirement value of existing equipment.

Second—The higher cost of new equipment of modern design, due to the conditions of the labor and material market.

Third—The fact that certain types of existing power are suitable for conversion into more modern and efficient types, or, by the application of improved devices, are made more serviceable under present operating conditions.

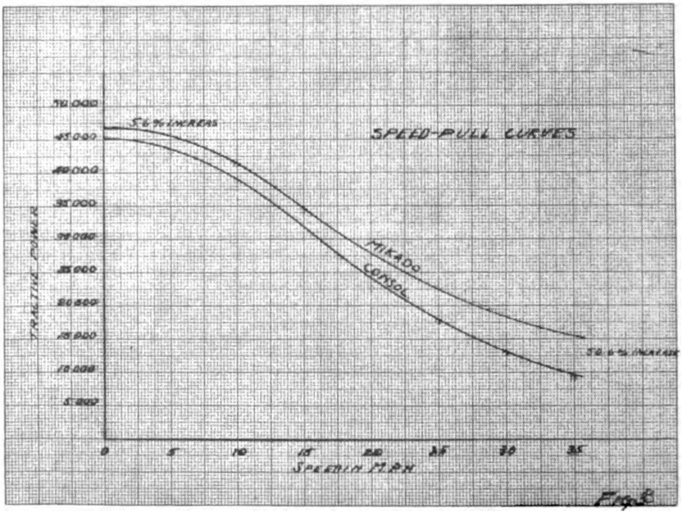
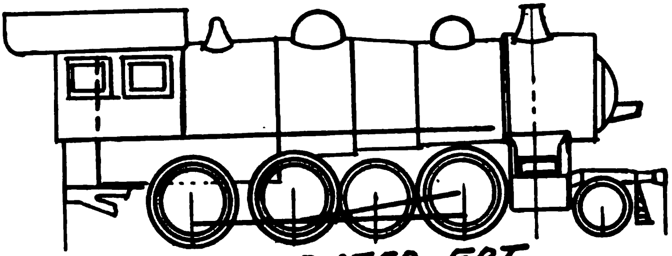
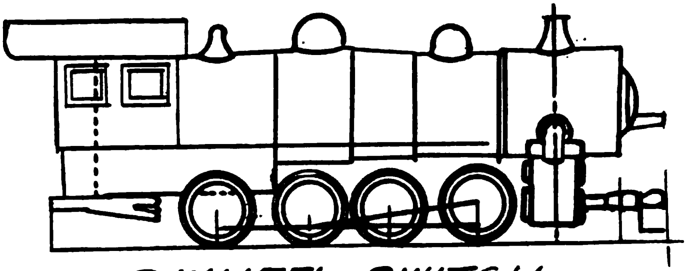


Fig. 3.

The two principal types of engines used in freight service during the past ten years have been the Consolidated and Mikado. In the purchasing of new power the Consolidated engines are being gradually displaced by engines of the Mikado type. It is, however, in the moderization of existing Consolidated engines or their conversion to engines of the Mikado type that the greatest amount of work has been done.



CONSOLIDATED FRT.



8 WHEEL SWITCH

Fig. 4.

Consolidated Frt.	SPECIFICATION	8 Wheel Switch
186,000 and 188,000	Total Wt. Engine	202,000
170,000	Wt. on Drivers	202,000
41,000 and 43,300	Tractive Effort	47,400
	Factor of Adhesion	4.26
22x30 in.	Size Cylinders	23x30in.
190 and 200	Boiler Press.	200
205	Heating Surface F. Box	161
2670	Heating Surface Flues	2110
376—2 in.	No. and Size Flues	173—2 in.
None	Heating Surface Sup. Heat	580
2875	* Heating Surface Equivalent	3141
119⅛	Fire Box Length	83⅛ in.
41⅛	Fire Box Width	75¼ in.
34.	Fire Box Area (Grate)	43.4 in.
Stevenson	Valve Gear	Walschaert
Richardson Balanced	Size and Type Valve	12 in. Piston
57 in.	Dia. Drivers	57 in
Hand	Reverse Gear	Ragonet (Power)
4.15 and 3.96	Wt. on Drivers÷Tractive Effort	4.26
815 and 857	T. E.×Dia. Drivers÷Equiv. H. S.	860
84.5	Equiv. H. S.÷Grate Area	72
7.68	Fire Box H. S.÷Equiv. H. S. %	5.1
63.7	Wt. Drivers÷Equiv. H. S.	64.3
69.5	Total Wt.÷Equiv H. S.	64.3
13.2	Vol. Both Cyls.	14.4
202	Equiv. H. S.÷Vol. Cyls.	218.1
2.58	Grate Area÷Vol. Cyls.	3.

* Super H. S.×1.5+Evap. Surface

An example of the conversion of a Consolidated engine to a Mikado is that shown by Fig. 2. The advantages gained from the standpoint of greater hauling capacity may be better understood by an analysis of Fig. 3, the Speed-Pull Curve for the two types mentioned. From this it will be noted that by means of increased weight on drivers, greater heating surface and the application of the superheater, the starting power is increased 5% with a gradual increase in sustained tractive effort to 50% at thirty-five miles per hour. Without such extensive changes as those cited above, the application of Superheaters, Brick Arches and the Walschaert or other outside types of valve gear have greately increasd the efficiency of existing Consolidated engines. In the conversion of the Consolidated engines to Mikados the cost of locomotive repairs per engine mile has been reduced 15% to 20%.

The increases in train tonnage accomplished by the introduction of cars of greater capacity and more cars per train enlarge the demand on terminal yard switching facilities, which resulted in the design of switch engines of more pulling capacity and greater rapidity of movement. As the Mikado has been displacing the Consolidated engine so has the eight-wheel switch engine been displacing the six-wheel switchers.

The conversion of engines of the Consolidated type to eight-wheel switchers is more easily accomplished than the conversion to Mikados, as will be seen from Fig. 4, a comparison of an actual conversion. In addition to increasing the starting power by enlarging the size of the boiler and cylinders, plus the addition of the superheater, the quick movement of the engine is facilitated by the use of the power reverse gear. This greatly promotes the ease and rapidity with which the engine may be reversed in short switching service.

By the conversion cited above a new engine is obtained for approximately 60% to 75% of the cost if purchased as such from the builders or built new in the operating companies' own shops. It is possible to utilize the frames, wheels, axles and other parts of the running gear, except valve motion, of the original engine. A large number of parts are interchangeable with those on other classes of power in service. This reduces the number of repair parts necessary to be kept in stock. If conversion is made at the time the original engine is due for general shop repairs the four or five thousand dollars necessary for such repairs can be applied on the cost of conversion, reducing the cost of the new engine by that amount.

METERS FOR MEASURING GAS AND AIR VOLUMES.

By R. S. SHADE, '10.

In recent years decided progress has been made in the design and construction of apparatus for the correct measurement of large volumes of gas and air. This development has been due to the increased use of producer and blast furnace gas for power purposes and the extensive use of natural and artificial gas for heating and lighting. The first meters used measured each foot of gas as it passed through the meter, but when enormous amounts had to be measured, this method proved too costly because of the size and number of meters needed. Thus, a more efficient and less expensive type of meter was gradually developed.

On the market today there are three general types of meters that are being used for the measurement of air and gas:—

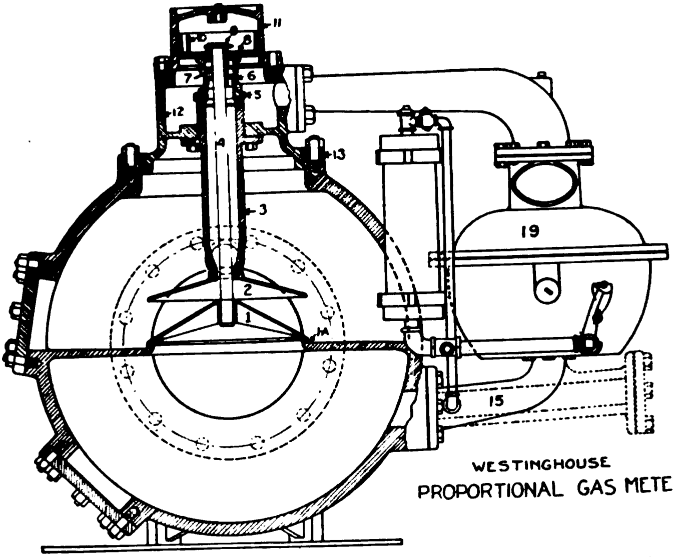
1. Proportional meters.
2. Meters whose construction is based upon the fundamental principle of $v = \sqrt{2 g h}$. This class includes the Orifice, Venturi and Rotary meters and the pitot Tube.
3. Thomas Electric meter.

PROPORTIONAL METERS

As the name signifies, the proportional meter measures the total volume of gas passed by accurately measuring a certain proportion of the same by means of a domestic meter. This proportion varies from 0.5% to 2%, according to the size of the meter. There are three makes of proportional meters now used, namly, the Westinghouse, Westcott and Wylie. The principle upon which these are constructed is the same for each, the only difference being in he mechanical arrangement of the parts.

The operations can be best understood by referring to the diagram of a cross-section, such as that of the Westinghouse meter shown below.

The gas in order to pass through the meter must raise the main valve (1) from its seat (1-A). In doing this, the tally valve (7), which is connected by a valve stem to the main valve, is also raised from its seat (5). The tally valve (7) slides up and down in the valve cage (6), which has a vertical slot in it. When the tally valve (7) is raised from its seat, the slot is opened and a certain amount of gas passes from the lower part of the meter through the meter inlet (15) and up through the tally meter (19), and,



WESTINGHOUSE
PROPORTIONAL GAS METER.

by the tally meter outlet (14), it passes through the slot in the valve cage (6), through the tally valve outlet (3), on into the line. The tally meter (19) is a small positive meter measuring each foot of gas that passes through it, but by a reduction gear arrangement the total volume of gas is recorded on the dial. This type of meter is used very extensively in the natural gas fields because of the fact that it will accurately measure large volumes of gas and can be easily transported from place to place.

METERS WHOSE METHOD OF MEASUREMENT IS BASED ON $v=\sqrt{2gh}$

The Orifice meter consists of a calibrated circular disc or orifice, which is inserted in the pipe line at right angles to the flow of the gas. The gas flowing through this orifice creates a difference in pressure, on each side of the disc, which differential pressure bears a constant relation to the volume of gas flowing. From the basic formula $v=\sqrt{2gh}$ a final formula $Q=C\sqrt{P\times H}$ is divided in which

Q=volume of gas passed during a stated period of time, usually fifteen minutes.

P=pressure of gas in pounds absolute.

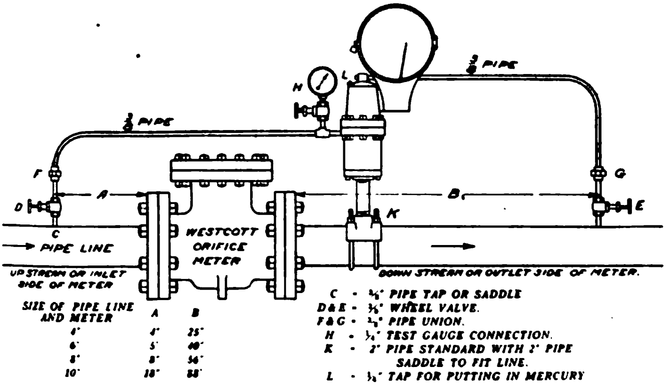
H=differential pressure in inches of water.

C=the gas co-efficient, which is the amount of gas passed through the orifice during a stated period of time, usually fifteen minutes, and 1 lb. absolute pressure and 60°

temperature of storage flow, and at an average differential pressure of one inch of water.

In practice, the co-efficient C is usually first determined for air and then calculated for the gas to be measured where the orifice is installed. As an example, suppose that gas of 0.6 specific gravity is to be measured on an 8 oz. basis co-efficient for

$$\text{Gas}=\text{Co-efficient of Air}\times\sqrt{\frac{1}{0.6}}\times\frac{14.41}{14.41+.5}$$


⅜ PIPE
⅜ PIPE
H
L
F
G
D
E
A
B
C
K
PIPE LINE
WESTCOTT ORIFICE METER
UP STREAM OR INLET SIDE OF METER
DOWN STREAM OR OUTLET SIDE OF METER.

SIZE OF PIPE LINE AND METER	A	B
4"	4"	25"
6"	5"	40"
8"	8"	56"
10"	10"	88"

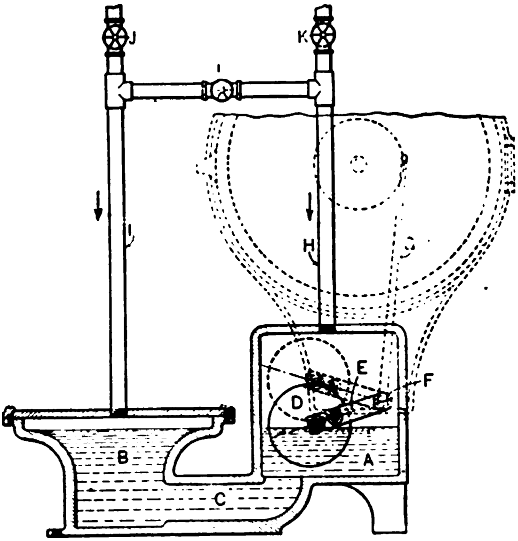
C - ¾" PIPE TAP OR SADDLE
D & E - ⅜" WHEEL VALVE.
F & G - ⅜" PIPE UNION.
H - ¼" TEST GAUGE CONNECTION.
K - 2" PIPE STANDARD WITH 2" PIPE SADDLE TO FIT LINE.
L - ½" TAP FOR PUTTING IN MERCURY

WESTCOTT ORIFICE METER INSTALLATION SKETCH.

WESTCOTT ORIFICE METER

The above sketch shows an Orifice meter installation—the orifice disc in this sketch is placed within the large casting designated as Westcott Orifice Meter. C is the pipe on the high pressure side of the orifice and G the pipe on the low pressure side of the orifice, both of which lead to the differential gauge L. C is usually located two and one-half diameters of the pipe line from the orifice on the upstream side of the flowing gas. G is located eight times the diameter of the pipe line from the orifice on the downstream side of the flowing gas. Until very recently, the one great disadvantage of the orifice meter was the gauge used in measuring the diffierential pressure. This was so delicate that under field conditions it was often ruined by an inexperienced man in manipulating the valves. This trouble now, however, seems to be adequately solved by the invention of the mercury float type of differential gauge. The following sketch gives a cross section view of one of these gauges:

It will be noted that there are two pressure chambers, (A) and (B), connected by (C). In this way the pres-



sure casing forms a U tube and the liquid employed therein is mercury. In the pressure casing (A), a cylindrical iron float (D) is outlined and this is connected rigidly by arms to the shaft (F) to which the pen arm (G) is fastened. The rise and fall of the liquid in the pressure chamber (A), therefore, causes the float and pen-arm to move about (F) as an axis. The dynamic or high static pressure is applied to the surface of the liquid in the compartment (B) through the pipe (I) and the low static pressure is applied to the surface of the liquid in the compartment (A) through the pipe (H). The difference between the two pressures acting on the liquid in the compartments (A) and (B) will produce corresponding differences of its level in these compartments, thus causing the pen to record the differential pressure.

VENTURI METER

When air or gas flows through a pipe in which there is a contraction, a difference of pressure takes place between the point of contraction or throat and any other point on the regular diameter of the pipe. This difference in pressure bears a constant relation to the volume of air or gas which is flowing. This is the principle of the Venturi meter.

The gas or air measurement is accomplished by the action of the pressure in the pressure pipes upon two large copper floats whose movements are transmitted through a series of gears and a cam to the dial of the register. This meter is especially adapted to places where its installation will be more or less permanent and where it can be looked after by a competent attendant.

PITOT TUBE

The Pitot Tube is a pipe of uniform diameter in which there are inserted two tips, one of which is placed at a point in the pipe diameter where the average velocity of the flowing gas is to be found. This velocity head is transmitted through the pipe tip to a U gauge, where it is shown in inches of water. The static pressure of the gas is taken by a pipe which is screwed into the Pitot Tube at right angles to the flow of the gas. This pipe, however, does not project into flowing gas. With the velocity head being known and the pipe of a constant diameter the formula $Q=\sqrt{P\times H}$ is derived. This, it will be noticed, is the same formula as for the Orifice meter. One of the chief objections to the Pitot Tube is that an observor must be at each station to take the readings of the static pressure and velocity head at intervals of not more than fifteen minutes. Where the rate of flow has any great variation there must be a number of different sized tubes which can be taken out or put into service as needed. This is another objection to this method of measurement.

THE ROTARY METER

This meter is very simple in design. The flowing air or gas impinges against the vanes of a turbine wheel, the revolutions of which are transmitted by a series of gears to a recording dial. This meter is now coming into use in the natural gas fields.

THOMAS ELECTRIC METER

The Thomas Electric meter is based upon the fact that for a given gas it always takes almost the same amount of heat to increase the temperature of a cubic foot through a given range. With this fact as a starting point an apparatus was designed whereby the gas pressure through the pipe line could be heated electrically to a certain degree of temperature. Knowing the specific heat of each cubic foot of the gas and the amount of electricity required to keep the gas at a certain specified temperature, the volume passing can easily be determined. This meter is used where large volumes of gas are flowing and where electricity is easily obtained.

METHOD OF OBTAINING THE SPECIFIC GRAVITY OF GAS

Since the flow of gases varies inversely as the square root of the density or specific gravity of the gas, it is highly essential that the density be known for any gas to be measured. The usual means of determining this is by the Bunsen effusion method, which is by noting the rate at which a certain volume of the gas passes through a small orifice. The rate at which a like volume of air passes through the orifice is also determined. The specific gravities of the gas and air are then in inverse ratio to the squares of the rates of effusion.

SUMMARY

The meters described in this article are used for the measurement of either gas or air. In practice these meters are tested for correctness for a gas of 0.6 specific gravity. When the gravity is different from this, the proportional Rotary and Venturi meters are readjusted to measure correctly for this change in gravity. The Orifice meter simply has its co-efficient changed and the Thomas Electric meter the specific heat of the gas.

All gas that is measured should have its specific gravity determined at regular intervals because of this value not always being constant and because any great variation involves a considerable amount of money. The Proportional and Orifice meters are principally used in the measurement of natural gas, although the Rotary meter is now coming into prominence in this field. The Rotary and Venturi meters are the ones generally chosen for the measurement of artificial gas because of the conditions under which it is manufactured.

In conclusion then, the method of measuring a gas depends first upon the kind of gas, second, its volume, and third, the conditions under which the measurement is to be made.

CONSTRUCTION WORK IN THE PHILIPPINE ISLANDS.

By R. J. Buck, '07.

At the end of the Spanish-American War, when the United States came into possession of the Philippine Islands, the government of these islands was a military one and remained so until 1904. Considerable improvements were made during that time but, due to the unsettled conditions, they were not, as a whole, of a permanent nature. In 1904 the government was transfered from the military authorities to the first Philippine Commission, appointed by the late President McKinley. The policy laid down by this Commission has been followed to the present time. In carrying out this policy, the Philippine Commission divided the various branches of government into "Bureaus"; such as "The Bureau of Health", "The Bureau of Lands", "The Bureau of Public works", etc. The laws made by the Commission had in mind the conservation of the country's resources, the education of the people, the improving of their sanitary conditions, the surveying of their lands, the improving of their highways, etc.

The Bureau of Public Works has charge of all construction work in the Philippine Islands excepting that done by the military authorities and the City of Manila. It is organized as follows:—

1. Director of Public works.
2. Consulting Architect.
3. Chief Designing Engineer.
4. Supervising Engineer, Department of Mindanao and Sulu.
5. Chief Construction Engineer.

The Director of Public Works has charge of all construction work done by the Civil Government. He is responsible for many millions of dollars' worth of work each year. He has as his assistants a "Consulting Architect", who plans all buildings erected by any branch of the government; a "Chief Designing Engineer", who designs all bridges constructed in any part of the islands and checks the plans of the Consulting Architect as to their structural safety; a "Supervising Engineer" of the Department of Minanao and Sulu, which is the section of the islands inhabited by the Moro tribes and whose laws do not come under the jurisdiction of the two branches of the Philippine Legislature; and a "Chief Construction Engineer", who is in direct charge of all work performed in the thirty-six Christian Provinces.

The Chief Construction Engineer has as his assistants a Superintendent of Artesian Wells, a Highway Engineer, a Supervising Engineer, who handles special problems, and thirty-six District Engineers (one in each of the Christian Provinces).

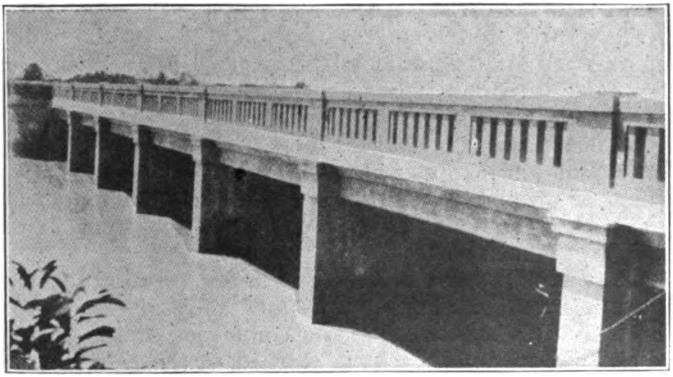
The actual construction work comes under the direct charge of the District Engineer. It is he who makes all highway locations, bridge site surveys, building site surveys, superintends the construction of all highways, bridges, buildings, parks, and maintains them in first-class condition. He makes all estimates for this work and submits them to the proper authorities for approval and securing of funds. After this approval is given he advertises for bids. If satisfactory bids are received, a contract is let for the work, but if the bids are above the estimate made by him, the work is done by administration.

In 1908 the First Pilippine Legislature ordered an investigation of the road situation to form an estimate of the cost of building a road system which would be adequate to the needs of the country at that time. The gathering of this data was performed by the engineers of the Bureau of Public Works. The report estimated that the cost of the system, including maintenance during a construction period of seventeen years, would be $37,000,000. The system laid out has been practically completed after the elapse of eight years at an expense of only $18,000,000. This money has been paid from the revenues of the government, and the roads, excepting a few instances, are free from debt.

There is in use today in the islands more than 3,000 kilometers of first-class road, more than 2,000 kilometers of second-class road, and more than 3,000 kilometers of third-class roads. First-class roads are well graded and surfaced, drained and constantly maintained. Bridges and culverts are usually complete and permanent. Second-class roads are fairly well graded, practically or naturally surfaced and maintained at intervals. These roads are generally open to traffic the entire year. Third-class roads are all other roads for cart traffic not included in the first or second-class roads. They are generally impassable during the rainy season.

All roads are relocated to correct alignment and grade. Gravel and stone roads predominate and adequately meet the country's needs. The authorities do not have to contend with freezing and thawing, the greatest enemies of good roads. As soon as a road is constructed and declared a first-class road by the proper authorities, a system of maintenance is placed in effect. This system is known as the "Caminero System". A man, called a Caminero, is placed in charge of each and every kilometer of road. It is his duty to keep all refuse off the road each day, to keep the slopes built up, the ditches clean, the grass cut and the small ruts filled with material of which the road is made. In case the repair work should get beyond his control a gang is sent to his assistance. In this manner the roads are kept in first-class condition.

All bridges constructed in the islands are intended to be permanent. They are, as a rule, of standard design. Box culverts are used where the span and the depth of stream vary from one to five meters. Above five meters slab and girder bridges on piers or concrete piles are, as a rule, constructed. Usually a row of five concrete piles, eight to ten meters in length, are driven to penetration and, when capped, form the piers for the slab and girders.

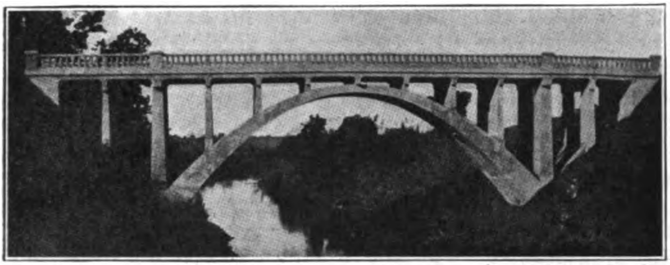


View No. 1. Bridge 0.40 Pontevedra-LaCarlota Road.

This bridge is of slab and girder on concrete pile construction. Over all length is five meters consisting of seven spans of seven meters each and curved wing wall at each end with a radius of two meters. Nine meter piles were driven to penetration and capped, which formed the piers and abutments for the girders and slabs. Filipino labor was used entirely.

The definite system laid out for years in advance included many large bridges of which this is an example. Permanence is desired, and in the tropics concrete is the answer.

The District Engineer also has charge of the construction of all school buildings, market buildings and any other buildings which the government should deem necessary and which lie in his province. The school buildings are of standard design. A unit consists of one room seven meters by nine meters. The buildings run from from one to twenty units, depending upon the section in which they are built.



View No. 2. Some streams require different treatment as here shown.

Market buildings, usually constructed in the municipal centers, are reinforced concrete with plain concrete floors and galvanized roofs and are open on the sides. These buildings are built from standard designs, the length being the only difference.

Various other improvements are being made at all times, such as docks, wharves, breakwaters, artesian wells, construction and maintenance of light-houses, water works, parking of grounds surrounding government buildings, etc. This work is all handled by the District Engineer in the province in which it lies.

In conclusion, the success of the organization depends on the personnel employed. No finer body of men can be found anywhere to-day than the employees of the Bureau of Public Works. They have worked in the past and are working to-day as with one mind the conserving of the resources and the improvement of the conditions surrounding the Filipino people. The American people have sent them there for a purpose and, as is the case of the American Engineer, they have all made good.

THE CONSTRUCTION OF LOCK AND DAM No. 34, OHIO RIVER.

By E. A. SMITH, '12.

In the River and Harbor Act, approved June 25, 1910, Congress adopted a project for increasing navigation on the entire Ohio River, with a view to obtain a minimum navigable depth of 9 feet throughout the year. Originally the project included the construction of 54 dams and locks, but this number has since been modified to 53. Lock and dam No. 40 may be dropped from the project by raising the dam at Louisville (known as No. 41) to such a height that it will cause the required depth at No. 39, which is about 75 miles further upstream. Of the 54 locks and dams 16 were in operation in January, 1916, 18 were under construction, and 19 had not yet been started. The act provides that the work be prosecuted with a view to its completion within a period of 12 years, but at the present time the progress of the work seems to show that it will take longer to complete the undertaking. When the construction of a lock and dam is to be done by contract, it has been found that the work is conducted most economically by placing it, with the exception of certain movable parts, brick power-house, and lock-keeper's dwellings, under one general contract, which generally requires from 4 to 5 years to complete. The original project called for an expenditure of $63,731,488.00, but much in excess of this amount will be required due to changes in designs and the increased cost of labor and materials.

Considering the river as a whole, the low water periods are likely to occur between July 1st and December 1st; sometimes as early as April. High water stages may almost invariably be expected in December to continue with occasional moderate stages until April or May. Rather high stages, known as the June rise, occur in June or early in July. The fall rise begins as early as October and continues for the remainder of the season.

When proposals were advertised for the construction of Lock and Dam No. 43, no bids were submitted and it was decided to do the work by hired labor. The United States War Department Corps of Engineers has charge of the work, as well as all other Federal improvements upon the Ohio River. No. 43 is the first project below Louisville, and is a distant of about 27 miles from that city. West Point, Ky., is the nearest settlement and is about 4 miles upstream from the site. The river is fairly straight for 1 mile below and 4 miles above this point, and the banks are rather high, being above the ordinary high water line, although a flood stage of 50 feet or more will overflow both banks. The fact that on the Kentucky side the L. H. & St. L. R. R. swings in to the river bank at this point, was undoubtedly a determining factor in the selection of this site for the project. Here, the Government purchased about 5 acres of land and converted it into a storage yard. Side tracks were provided and a ware-house 51'x100' was built. An incline track on an approximate 6% grade was constructed down the river bank to the low water contour, and a Mundy single drum mine hoisting engine was provided for hoisting and lowering cars up and down this grade. The boiler of this engine also furnished steam for operating the 3 drum Ledgerwood hoisting engine of a 6 ton stiff-leg derrick at the head of the incline. A traveling derrick was erected upon a set of 40 ton track-laying car trucks for handling the materials about the yard which were beyond the reach of the stationary derrick. Thus cars of materials could be either lowered down to the river and there be unloaded directly on to barges, or the contents could be unloaded and stored in the storage yard or storehouse.

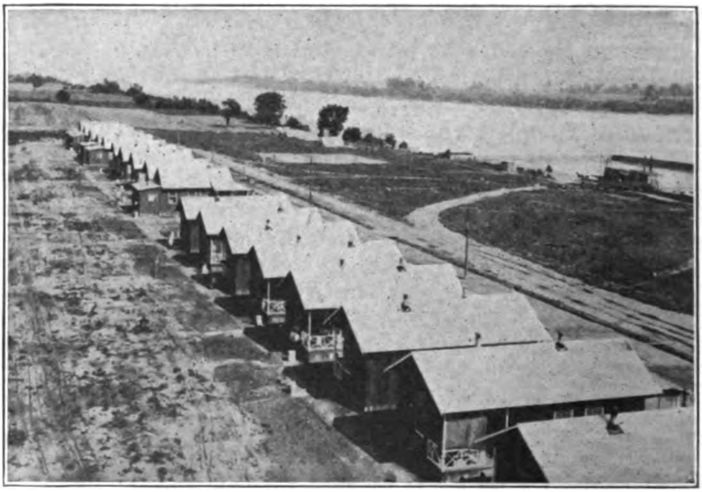


Fig. 1.

The greater part of the construction work is on or adjacent to the Indiana shore. The lock as well as the steam power house and 4 lock-keeper's dwellings are located on this side. Therefore, it was decided to build the construction camp on this side of the river.

On May 5, 1914, a tow, made up of floating plant and equipment arrived at the site. On the following day work was begun clearing off the ground and unloading materials from barges for the construction camp. The camp (Fig. 1) is located about 250 feet back from the river bank on a ridge gently sloping to and from the river, so that the drainage is excellent. The government rents the houses erected by it to the employees at reasonable rates and maintains sanitary conditions in the camp.

The construction work consists of the erecting of a lock 110 feet wide by 600 feet between gates, upper and lower guide walls, navigable pass extending from the river wall 800 feet into the stream, 540 feet of bebout weir, 3 piers 91 feet to bear trap dam, 279 feet of fixed weir, and an abutment on the Kentucky side.

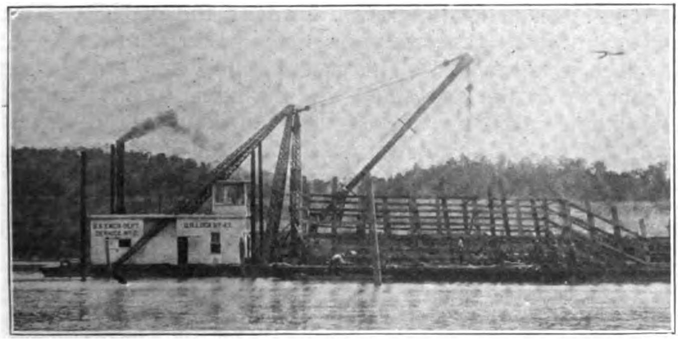


Fig. 2.

The lock coffer dam, 2280 feet long, incloses the entire lock and lower guide wall, an area of about 13 acres. It is the ordinary Ohio River box type coffer, 20 feet wide, to top being 18 feet above mean low water. Fig 2 illustrates the method of construction. The skeleton, consisting of tie rods and vertical 2"x12" plank spaced 6 feet horizontally, was first erected on a barge. It was then lifted by a derrick boat, the barge moved ahead and the skeleton dropped into place in the river. One bent was always left on the barge to facilitate construction. Following the erection gang was a sheathing gang which drove vertical sheathing and nailed 1"x3" batten strips over the cracks. Floating pile drivers drove 25 foot W. S. steel sheet piles entirely around the outside of the coffer. The space between the top of this row of piling and the coffer damn was then filled with concrete about 4 inches thick. The inside of the coffer was then filled and the outside banked by derrick boats and hydraulic dredges. Part of the excavation from the lock was used to fill and bank the coffer, the balance being dumped into the river.

Much difficulty was experienced in getting the piling down to the proper penetration of 30 feet. At a depth varying from 15 to 20 feet a layer of cemented sand and gravel gave trouble.

For mixing concrete, a mixing plant was installed upon the lower end of the coffer dam. It consisted of 2, 1½ yd. Smith mixers, above which were measuring hoppers fed by a sand and gravel bin. Two ten ton capacity stiff leg derricks unloaded the sand and gravel from barges into the bin, and also unloaded cement from a cement barge. A dredge with screens for washing and separating the sand and gravel furnished these materials. The mixed concrete was dumped into Lockwood automatic dump buckets on flat cars, which were transported by 7½ ton, 36″ gage Vulcan locomotives. Two 15 ton capacity Link Belt locomotive cranes dumped the buckets of concrete into place in the walls. The use of dump cars for placing the concrete in the lock floor was the more speedy method as it obviated the handling of the cranes. A maximum of about 500 yards of concrete was placed in an 8-hour shift.

The permanent construction inside the lock coffer dam was completed in September, 1916, and the construction of the coffer immediately began by inclosing the 500

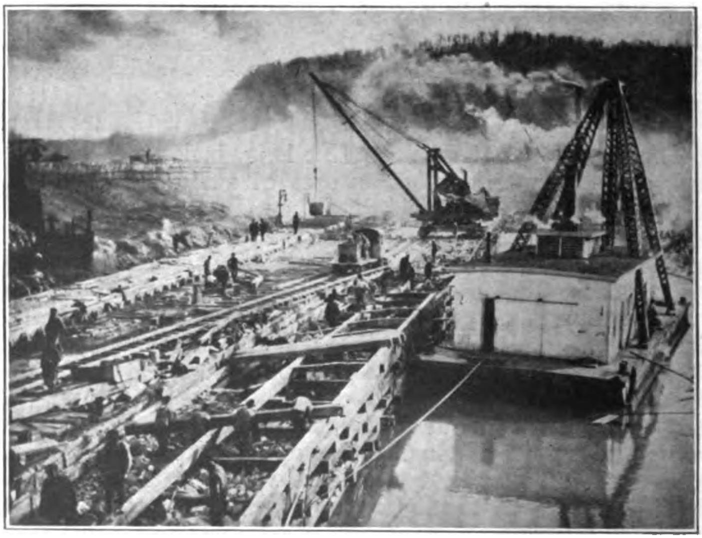


Fig. 3.

feet of navigable pass adjoining the river wall. This coffer was similar to the lock coffer dam with the exception that the steel sheet piles were omitted. Fig. 3 is a view taken from the Indiana bank during the construction of the navigable pass coffer dam. In the immediate fore ground is the land wall, beyond is the river wall. Beyond this and running parallel with the walls is the lock coffer, not yet removed. Still beyond this is the navigable pass coffer. Note the lower gate recess in the land wall, and the square opening in the river wall not entirely covered by water. Seventeen of these openings are for the purpose of admitting water into the lock and bringing the surface inside to the upper pool level. The other seventeen openings, seen in the picture, are for the purpose of bringing the water surface in the lock to lower pool level.

The excavation was done with three derrick boats and a dipper dredge. Much of the material was handled twice in order to use it as banking and fill in the coffer, very little of it being scowed outside.

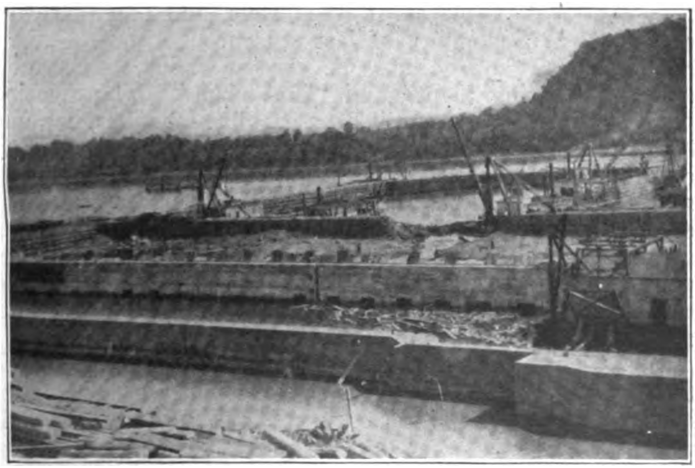


Fig. 4.

The crib, 20 feet wide by 16½ feet deep, was constructed in the wet before the excavation was completed and the coffer dam closed. After closing the coffer, the crib was floated into place and allowed to settle as the water was pumped down. The crib was filled with rock by the derrick boat, Fig. 4, which transmits the rock across from the coffer dam where they were unloaded from barges by the derrick boats. Dinky locomotives operating on the crib also assisted in the filling. A solid hardwood deck was drifted onto the crib after filling was completed.

Thirty feet round piles, 6 ft. centers, were driven for a foundation, and 40 foot steel sheet piles were used along the upstream side of the concrete to prevent the water from undermining the foundation, both sheet and round piling being sunk with skid drivers. Excellent records were made in driving both kinds of piling—32 to 36 round piles for one driver for an 8-hour shift was the standard, while a maximum of 32 steel sheet piles were driven in an 8-hr. shift by the vulcan hammer.

All work was completed inside this coffer dam, except the placing of the rip rop below the crib, when high water made it necessary to move the plant, December 19, 1916. The rip rop, 60 ft. wide, is being placed by derrick boats during the winter season.

The work during the coming season will be to complete the construction of the dam across the river. Two coffer dams will be necessary, each enclosing about 600 ft. The abutment, 164 feet of fixed weir, and one pier was completed in September of last season.

The plant in use may be classed under two heads; namely, "floating plant" and "land plant." The floating plant consists of: 1 steam boat, 2 gasoline launches, 1 pump boat, 2 15-ton capacity derrick boats, 1 sawmill boat, 3 quarter boats, 3 floating pile drivers, 1 machine shop boat, 2 12" hydraulic dredges, 8 steel barges, 2 flat boats for erecting coffer skeletons, 2 anchor floats, 28 pontoons for supporting pipe line, and 6 skiffs. Besides these, other pieces of plant, such as dipper dredges, bucket dredges, maneuver boats, steam boat, etc., have been borrowed or rented for use at various times.

The land plant consists of 2 15-ton capacity locomotive cranes, 3 7½-ton, 36" gage locomotives, flat cars, dump cars, 2 1½-yd. capacity concrete mixers, 1 ¾-yd. capacity concrete mixer, power house, derricks, skid pole drivers, etc.

When operating full force a total of about 500 men make up the two shifts, employed in both camp and construction.

MAKING A PROFIT FROM EXHAUST STEAM.

By J. C. Lewis, '09.

The use of exhaust steam for heating purposes is certainly an economy. Only recently South Whitley, Ind., reduced taxes by making a change in the heating system of its school house. The gravity furnace heating system in the eight-room school building having become inefficient and practically inoperative, it was decided by the School Board to remove the furnaces and install an up-to-date steam heating system, consisting of a motor-driven blast fan in the basement furnishing tempered air to all the rooms in sufficient quantities to meet the requirements of the Indiana State Board of Health, together with sufficient direct radiation in each room to take care of wall and glass exposure.

The Town Power Plant, located only a short distance from the school, on another street, had for years allowed its exhaust steam from the 150 H. P. and 75 H. P. engines to waste into atmosphere. Here was, ready made, an opportunity to make us of this exhaust steam in heating the school, with a possible saving to the taxpayer of at least an amount equal to that previously spent for coal in firing the school furnaces.

The Town Trustees, realizing this condition, made the following proposition to the School Board: i. e., that they (the Town) would pay for all necessary changes in connection with the power plant and pipe the steam up to within the building wall of the school, in return for which the School Board was to guarantee to install a vacuum system of heating in the school and pay to the Town an annual sum of money equivalent to the amount of their previous average annual coal bill. This the School Board was entirely willing to do, realizing that it was being saved the cost of two large boilers, piping and valves around the same, the space in the basement occupied by the boilers and coal room, the dirt and noise incidental to firing, and the labor of their janitor.

Accordingly plans and specifications were prepared and two separate bids were taken, one by the School Board and one by the Town Trustees. Only the work inside the school was let to a heating contractor, as several of the Town Trustees were practical men, entirely capable of buying the material and letting sub-contracts for their portion of the work, which was accordingly handled in this manner. The work was started in August of 1916 and so well did the two branches of work co-ordinate that by the last of the year the contracts were completed and the school had been successfully heated with steam from the power house throughout all of the cold weather without disturbing the school routine.

In the school house the furnaces were torn out, new brick heat and vent flues installed where necessary in order to conform with the State Code, and the vents capped above the roof with Ventilators. Thirty-six radiators containing approximately 1,900 sq. ft. were installed in class rooms, cloak rooms, and corridors. In the basement was installed a 36″ multiblade centrifugal fan, belt driven by a five-horse-power motor. Galvanized ducts suspended from the basement ceiling conduct the air from the fan discharge to the various warm air vertical flues.

The fresh air is drawn in through screened openings from the outside, and warmed before entering the fan by passing through two stacks of cast iron Vento sections at a velocity of 1,000 ft. per minute. Sufficient space was left between the two stacks so that an air washer may be installed at some later date. There are 1,120 sq. ft. in the two stacks of Vento sections. The temperature of the air leaving the fan outlet is automatically controlled by means of air operated diaphragm valves placed in the steam connections to the Vento sections. A small air compressor is belted to the fan shaft.

Thermostatic vacuum traps with metal diaphragms are connected to the return end of each unit of radiation and blast sections at ends of mains, and all low points in mains, and a vacuum return main carried on basement ceiling to the point where the trench enters the building.

The Town Trustees installed a 24-inch square concrete trench, 700 feet long, in the alleys between the school and power house, carrying both the supply and return mains parallel in the trench, and giving the supply main a pitch of one inch in ten feet back toward the power house. The top of the trench was covered closely with wooden slats, over which was poured three inches of concrete. Only two manholes were used, and the drip traps and expansion joints located therein. Five service tees were placed in the lines for easy future connection to adjacent residences. The supply main is covered with asbestocel, painted with black asphaltum. Both supply and return mains are supported on rollers.

It might be interesting to note that for the 8″ and 6″ supply, and the 3″ and 2 1/2″ return pipe, the average cost of pipe and fittings, delivered, was $1.18 per lineal foot of trench; the cost of covering, delivered, was 60c; the cost of trench, including manholes, roller supports, excavating and back-filling, was $1.75 per lineal foot; and the cost of the trench, with pipe installed complete, was about $4.00 per lineal foot, including all labor, expansion joints, traps, etc.

The work in the power house consisted in making some changes in the piping arrangement around the feed water heater, so that the 6″ and 4 1/2″ engine exhaust and the 4″ water pump exhuast can be either exhausted into atmosphere or thrown into the new 8″ heating main run across the ceiling of the power house and connected to the main in the trench. An oil separator was placed in the heating main and a by-pass connection made from the high pressure main through a pressure reducing valve into the heating main.

A back pressure valve was set in the exhaust line to atmosphere and the top of this line capped with a cast iron exhaust head.

The vacuum pump installed lifts the water of condensation a height of seven feet from the low point of the vacuum return main where it enters the pit in one corner of the power house and discharges the condensation through an air separating pipe loop into the top of the feed water heater.

The cost of all the above apparatus in the power house was about $1,000 installed, making a total investment for the Town of approximately $4,000.

The supply and return mains in the trench, and the apparatus in the power house are of sufficient size so that, besides heating the school, an additional load of 10,000 sq. ft. of radiation may be carried, or about 30 residences averaging 350 sq. ft. each. Estimating roughly that this 10,000 sq. ft. would condense 5,000,000 pounds of steam per season, a charge of 50c per thousand pounds to the consumer would bring a revenue to the city of $2,500 per season.

Add to this the very nominal sum of $300.00 per season charged for heating the school and we have a total possible gross income of $2,800.00. With the present investment of $4,000.00 and a future roughly estimated sum of $3,000.00 spent for making service connections to 30 residences, the Town will have invested $7,000.00 total for the exhaust steam heating system. Interest and depreciation at 10%, placing the life of the new apparatus at only 10 years, would amount to $700.00 per year. No other items of expense need be considered in connection with the improvements, as no additional labor is involved in operation. The net income, then, would be $2,100.00 per year, or a profit of 300% on the investment.

FLOOD PROTECTION AND PREVENTION IN LOS ANGELES COUNTY.

By H. M. Lukens, '12.

The streams of Southern California are peculiar and have characteristics distinctly different from those of the humid portions of the United States.

The mountains in which practically all of the streams have their sources are precipitous and so far as forests are concerned, quite bare. They are, in great part, of granite formation and from a geologic standpoint, new. The crest of the Coast Range, with elevations ranging from 5,000 to 10,000 feet, lies but 50 miles inland from the coast of the Pacific Ocean. The steep slopes of the mountains are cut by the rims of the valleys at the very general elevation of 750 feet. For several miles from the foot of these slopes the grades of the detrital cones drop quite rapidly until the much flatter floor of the Coastal Plain is reached. Down sharp gradients of from 200 to 1,000 feet per mile these streams suddenly debauch from their canyons upon the gentler grades and begin to drop the heaviest portions of their loads which they have been gathering up on their descent. The smaller portions are deposited farther and father from the mouth of the canyon.* Thus it may be seen how these cones of detritus are slowly built up as the mountains disintegrate, and how they spread out, sometimes for several miles, in a fan-like shape with the highest point at the canyon mouth as though a monstrous cone were placed there and partly buried. Since the stream flows on the highest part of the cone, it is likely to overflow and change its course to any part of the cone in time of high water. Passing over the cones the streams experience another change in grade and drop the finer materials in suspension, forming the fertile valleys of the Coastal Plain.

In the Coastal Plain, or valleys, the streams take on different characteristics. Here their velocities are much lower and in time of flood they will not confine themselves to a definite channel. The rivers spread over vast areas and in some localities deposit depths of sand and silt, causing the abandonment of many acres of land.

A stream has two methods of altering its course. The first consists in a gradual shifting of its position, one bank being eroded while silt is being deposited at the other. This kind of change is generally termed "Erosion." The second change consists in the scouring out of a new channel or the enlargement of a small one. Such a change is known as "Avulsion." Here in this locality, while erosion is continually taking place, the greatest and most frequent changes in the courses of the streams occur by the latter method, always, of course, during high water. A river may make for itself in this way a new channel, flowing peacefully through it for several years and then suddenly return to its old bed or a new one. As an instance of the instability of the Los Angeles River, which changes more frequently than the others, is mentioned the construction of a two span truss bridge by the S. P. Ry. Co. across said river during the summer of 1889. That same winter a momentous flood occurred and the river formed a new channel two miles from its old one. The bridge was left there in the hope that the river might some day again return home.

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*The transporting power of these mountain streams is enormous. The writer has seen boulders more than 10 tons in weight, a distance of two miles ormore from the mouth of the canyon. In one canyon is a boulder as large as an average sized bungalow, which is moved 100 feet or so downstream at each high water.

Beginning at the City of Los Angeles and continuing south to San Pedro Bay is a stratum of water-bearing gravel varying from one mile to two and a half miles in width underneath strata of clay and sand. Logs of the various wells that have been dug in this region show that this stratum has its source at an elevation of about 200 feet above the sea and gradually lowers to a depth of about 125 feet below sea level at the shore line, continuing out into the ocean. It has been ventured that were it not for this layer of clay and sand holding the water down, the lower Los Angeles valley would be a swamp, and this is probably true, since the head of water is sufficient to produce artesian wells in this vicinity. In this lower section there are daily fluctuations in the height of water in these wells, due to the difference in elevation between high and low tides. In the wells near the shore this daily tide effect is about three feet. At Bangle Station, a distance of four and a half miles north of the ocean, is a well the elevation of whose water surface is about 17 feet, in which the twice daily rise and fall is from one to one and a half feet. Some slight tidal effect is said to be noticeable in wells at Compton, 10 miles inland, where they are drilled into this stratum. The elevation of the water surface here is about 75 feet above mean sea level. Alkai, which is present in the surface wells, does not appear in these artesian wells. These conditions produce almost conclusive evidence that there is no relation between the surface flood waters or any other surface waters and the water in this gravel stratum.

RAINFALL

The average yearly rainfall in Southern California is about 15 inches, increasing in intensity with elevation as the crest of the Coast Range is reached. Practically all of it falls in the months of January, February and March, with occasional rains in October, November, December, April and May. Large quantities of rain fall in the space of a few hours and sometimes a storm continues for several days, the rain falling spasmodically and varying in intensity. After the soil is saturated, the run-off is rapid, due to the precipitous character of the mountains and the improvement of the country.

MAGNITUDE AND RECURRENCE OF FLOODS.

The frequency of destructive floods must be considered as well as their magnitude. In the case of Daneri vs. The Southern California Ry. Co., 1897, there was corroborated testimony given to the effect that there were heavy floods in the Los Angeles River in the years 1825, 33, 62, 67, 84, 86, and 89. The flood of 1889 was conceded to be the heaviest. The records of the U. S. Weather Bureau, established in 1878, give dates of serious floods as 1879, 87, 89, 90, 91, 1905, 06, 09, 11, and 1914. Allowing for floods which might not have been recalled from the early days—some old residents who were not witnesses at the above mentioned trial remember destructive floods in 1842, 52, and 74—it would not be unreasonable to expect two floods in seven years. Yet there have been several heavy floods in one rainy season, and floods in two successive years would not be unprecedented.

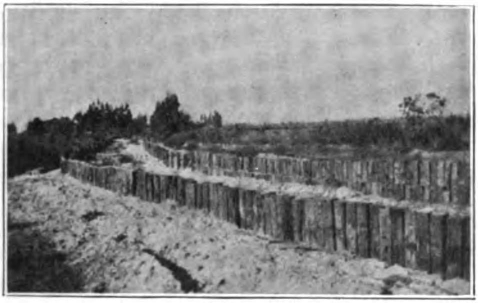
FLOOD DAMAGE

The actual damage to property alone during the flood of 1914 was estimated at ten million dollars. As the country becomes more densely populated, the damage will increase proportionately. The Los Angeles and Long Beach Harbors are subject to the deposit of silt with each high water from the Los Angeles River. During the flood of 1914 more than 4,000,000 cubic yards of silt were deposited there, causing injury to the harbors and delay to commerce.

FLOOD PROTECTION IN THE PAST

Flood protection in the past has been largely a matter of individual effort on the part of the party affected. It has consisted almost entirely in straightening and attempting to confine the stream to a channel. Several methods were used to accomplish this, such as wire fences backed with brush and rocks, levees of earth and gravel, heavy plank fences and willows, bamboo, etc.

In 1911 the San Antonio Protection District was formed to protect a section of the San Gabriel River which was particularly menaced by the high waters of 1910-11. The work was finished in 1912 at a total cost of $137,000. It consisted in the main of wing piling faced with barbed wire and driven along the cutting bank. The flood of 1914 broke through the protection work in a number of places and caused practically a failure of the project. Four small protection districts were also formed and work done which proved entirely inadequate. In some cases positive harm was done. Quite often the washes, where the channel is small, are cultivated over and all traces of the wash removed.



Eaton, Wash., showing protection made of old railroad ties.

FLOOD PROTECTION IN THE FUTURE

The futility of these small and disconnected efforts to control and prevent serious floods has been realized and resulted in the organization of the Los Angeles County Flood Control District, authorized by act of the state legislature and under the guidance of the County Board of Supervisors. In April, 1914, this board appointed a commission of five well known and experienced engineers to prepare a comprehensive report on flood control and flood protection. Following the submission of their report, a chief engineer was appointed to take charge of detail surveys and plans after the general suggestions of the Board of Engineers. His report has been recently submitted to the Board of Supervisors. Three main objectives have been kept in view throughout the report:

1. Adequate protection of harbors.
2. Conservation of as large a proportion of flood water as it is possible to impound or force into underground reservoirs.
3. Reclamation to usefulness of areas now abandoned because of overflow or threatened destruction.

To accomplish these things, three general methods of control and prevention have been followed:

1. Storage reservoirs.
2. Channel rectification, levees, river training and "spreading".
3. Impeding dams, or check dams, in the smaller streams of the mountains.

Unfortunately there are few good sites for storage reservoirs. Four will be made. One dam is to be built in the Pacoima Wash Canyon, of concrete 145 feet high, impounding 3,200 acre feet of water; one across the Arroyo Seco, of concrete, 130 feet high, which will impound 6,600 acre feet; one in the San Dimas Canyon, 145 feet above bedrock, which will impound 2,500 acre feet; and an earthen dam at the head waters of San Jose Creek with a storage capacity of 2,250 acre feet. It is thought that in all cases the impounded water will seep through the porous strata and raise the level of the water in the underground reservoirs. Should this not prove true, it can be used directly for irrigation purposes.

The type of bank protection will, in general, eonsist of either a boulder levee thrown up by steam shovel, a single row of fencing, or a double row of fencing filled in between with orchard cuttings or brush and weighted down with rocks.

In handling the three major streams, the Los Angeles River, the San Gabriel River and the Rio Hondo, training works will be built that the rivers may help to govern and straighten themselves. The training works will be comprised of a double row of piling about 5′ apart, on the stream face of which will be placed wire fencing, and the space between filled with brush and rock. In all cases the growth of willows and other trees with deep, firm root systems will be encouraged along the banks and back of the protection. An earth diversion dam is to be built at Dominquez Hill to divert the water of the Los Angeles River from its present disastrous channel and make it flow between the Long Beach Harbor and the residential section of the City of Long Beach. This change will free the harbors from danger. Federal aid has been obtained for this portion of the work.

The term "check dam" has been applied to any artificial obstruction of stone or logs or combination thereof, placed entirely across a stream bed. A series of these check dams is built down a rapidly descending mountain stream, producing a number of falls and a flat grade between. The effect is to reduce the velocity of the water to such an extent that it can be absorbed and rendered harmless. These dams are from 4 to 8 feet high. The height and distance apart depend upon the conditions of side and bed rock and the grade of the canyon. They will be placed in nearly all the head waters and smaller streams of the mountains.

Reforestation of the mountain slopes is a phase of flood preventation which is given precedence in European countries but which has not been given consideration here at this time because of the length of time required for sufficient growth. In this locality, from 8 to 10 of the 12 months of the year are dry, limiting the growing of trees and producing a serious menace from fire even after the growth is started.

The importance of this work can not be overestimated. The very life of Southern California depends upon its agricultural and orange growing districts, which in turn depend upon safety from flood dangers and upon the water in the underground reservoirs as well. Conservation of the annual rainfall is necessary to maintain them. At present the accomplishment of this work rests with the voters of the county, who are asked to vote enough bonds to pay for it. With no precedent to follow, the development of these proposed works and their effects will be watched with great interest.

HIGH VOLTAGE LINE INSULATORS.

By J. B. Sheadel, '11.

Electrical insulators have two functions to perform; one supporting the wires, the other, insulating the wires. Hence there are two kinds of stresses brought to bear upon the insulator; mechanical and electrical. With low voltage lines the mechanical stresses are much geater than the electrical stresses, so that if an insulator is sufficiently strong mechanically, very little attention need be paid to the electrical stresses. But with high voltage lines the electrical stresses are very large and often become the ruling factor in insulator design. In fact, on high voltage lines it is much more common to have the insulators break down electrically than mechanically.

Today, high-voltage line insulators are made of porcelain. This material possesses several advantages over other materials for this purpose, some of which are cheapness, high dielectric strength, high ohmic resistance and reasonable mechanical strength. The principal objections to its use are that it is easily broken and its length of life is short (many insulators breaking down electrically in four or five years).

Insulators have been developed more by the "cut and dry" method than on a scientific basis. This is due to the fact that the demand for insulators came before the conditions under which they would have to operate were thoroughly understood. A good factor of safety has always been allowed as far as voltage is concerned, the insulator being built to stand about three times normal voltage before flashover occurs in dry air. Also, it was early realized that the insulator should flashover at a lower voltage than that at which it would puncture. But there were no provisions made for abnormal conditions other than abnormal voltage and there was no knowledge as to the length of the life of an insulator. Surges, for example, due to switching and lightning, have a very steep wave front which is quite injurious to the insulator.

Because of the above mentioned method of development, it is not surprising to have defects appear. One very serious deficiency has appeared. After insulators have been in service a few years many punctures occur which lead one to think that the life of a porcelain insulator is comparatively short (some cases less than five years), whereas it was supposed to be infinite from an electrical point of view. This failure of insulators after a comparatively short period of service has led to a movement demanding more rigid or different tests, the idea being to provide a test or a series of tests which, more nearly than the old ones, imitate the conditions met by insulators in actual practice. Some insulator manufacturing companies claim that the tests are not at fault and are putting more attention into the manufacturing processes. But the utility companies, the consumers, are demanding better insulators and their way of obtaining them is by better tests.

The details of testing insulators are not standardized to any great extent and each company tries to carry out some of its own ideas. However, there are three general methods of testing high voltage line insulators. The first test used and very extensively employed is the method referred to above, of impressing voltage at low frequency (generally 60 cycles) over the insulator and gradually increasing the voltage until flashover occurs. (See Figure 1).

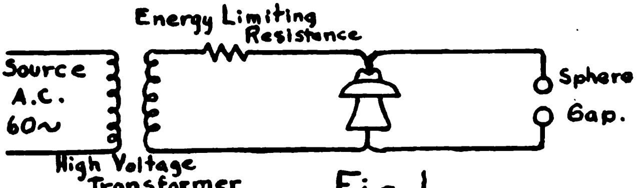


Fig. 1.

Circuit for impressing low frequency on an insulator.

It is claimed that if puncture does not occur, that is, if the insulator passes the test, no damage is done because the flash takes place through the air and not over the insulator.

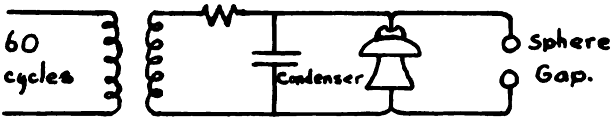


Fig. 2.

Here the insulator is subjected to high frequency superimposed on low frequency.

The second method uses a high frequency superimposed on the low frequency. This is accomplished by a circuit as shown in Figure II, the values of capacity and inductance being adjusted for resonance at a high frequency. It is claimed for this method that when the stress comes on the insulator, the condition is very similar to that existing on a line when lightning influence or a surge occurs. In the third method only high frequency is impressed on the insulator. This is accomplished by a resonant circuit as shown in Figure III. It is claimed for this method that the high frequency current which follows the surface of the insulator searches out the cracks and defects. Utility companies are demanding this test more and more, as they think it gives better results. But the manufacturers object on the ground that it is too severe on the insulator. In addition to these tests, there is a resistance measurement of the insulator made just before packing at the factory, and all insulators measuring less than infinity are discarded.

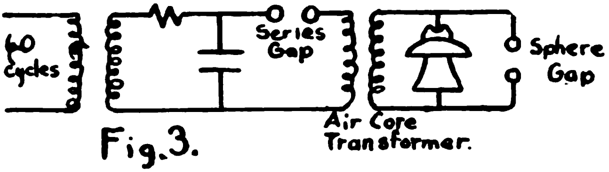


Fig. 3.

Here only high frequency is impressed on the insulator

As stated above, after insulators have been in service a few years many punctures occur and it appears that they gradually weaken. Much research has been carried on recently to discover the cause of this weakening. In the High Tension laboratory at Purdue, extensive experiments are being made to determine the relative value of the various tests on insulators and the cause of insulator weakening. Most engineers agree that this weakened dielectric condition is due to moisture absorbed by the insulator. So general is this feeling that large utility companies go over their lines about once a year and discard all insulators which "megger" less than infinity. But all do not agree as to why insulators absorb moisture. Some say that procelain is hygroscopic and moisture is gradually taken on, and when a sufficient amount has been absorbed, breakdown occurs from abnormal line voltage or possibly normal line voltage. Others claim that small cracks develop in the insulator and moisture is taken on, thus reducing the dielectric strength and ohmic resistance. There is also a diversity of opinion as to why these cracks develop. It is claimed that they may be caused by internal stresses due to uneven cooling at the time the insulator is made or because of electric stresses due to high voltage on the line, or because of changes of temperature from day to day or season to season.

If some porcelain insulators have the property of absorbing moisture gradually and in the course of a few years becoming weakened to such an extent as to be practically worthless while other insulators do not, then it seems as though we may hope to develope a test to eliminate the poor ones or to improve the manufacturing proçesses. On the other hand, if it is a property of all porcelain insulators to gradually weaken and become worthless in a few years then it seems that there should be a new material developed for line insulators. There have been some attempts made to use compounds similar to bakelite, but as yet no successful development has been made public. The course for the immediate future seems to be a complete study of the present insulator to learn whether or not the defects can be remedied, and also a search for another material better suited than porcelain for high voltage line insulators.

CENTRAL STATION STEAM HEATING.

By Harry A. Woodworth, M. E., Purdue, '09, '13.

Heating a business or residence section of a city or town by a system of properly insulated steam mains was first done successfully at Lockport, N. Y., some forty years ago and the same plant, with its original underground installation of hollowed wood log, is still in use today after all these years of service, extensions having been made from time to time as business warranted.

REASONS FOR DISTRICT HEATING

District heating has proved profitable in territories where natural gas and cheap domestic coal are at hand. Since the price of coal is on the advance, with the drawbacks of delivery of fuel, unsatisfactory burning, and the enactment of rigid smoke abatement ordinances, there has been an unusual growth in the installations of central station steam heating. The isolated plants in office buildings, hotels and industrial buildings have been shut down, due to the fact that they could buy steam for heating, cooking, laundry and manufacturing. Central station heating has been the cause of greater light and power load for all combined heat and light utilities. Without the heat, the above class of business could not be contracted.

Present day utilities are operated on so narrow a margin of profit that the increase in fuel prices, with no increase in the selling price of their commodity, has caused the water, gas and electric companies to find a double use of their power plants by selling their by-products.

Central station heating is a necessary convenience desired by all communities. It is a marked source of profit to the utility companies due to the double utilization of each pound of coal. Where the plant is operated as an electric and heating utility, much better returns have accrued from the conjoint operation than from an independent electric plant wasting the steam to the atmosphere or condenser. The economies resulting from one management, one boiler plant replacing many, greater earning power derived from one pound of steam, higher grade of labor and engineering, a general saving in operation and investment, established good reasons for the increased demand by most utilities to adopt central station heating.

Since the advent of the various state Public Service commissions the public utilities that operate combined heat and light plants have been compelled to segregate the costs of each commodity on a just and equitable basis and this segration of costs has proved that the central heating business has been the "goat" in the past. The ambition of certain companies is to manufacture a kilowatt-hour on paper at a cost less than the other utilities so that they may be considered the most "efficient" plants. In order to do this the light and heat company has charged electric maintenance and operation to the steam heat department and often credited certain heat revenue to the electric department as non-operating revenue, while the heat department stood the major portion of the burden. Out of this chaos has come an effective revision in practice, naturally followed by greater confidence in the utility of central station heating. In the main, this has logically come about through more skilled engineering, more durable and efficient insulating materials, equitable and adequate meter basis of charge, wisely selected territory and proficient management.

PREPAREDNESS

The demands for central heating is so strong in general that the manufacturers of prime movers have revolutionized the design of their steam units to make provision for operating these units efficiently, both condensing and non-condencing, as the conditions may demand. The Bleeder type turbine is the offspring of central station heating. Many electric utilities are selecting this type of unit where their plants are favorably located for central station heating, even though no heating system exists at present. This type costs very little more than the standard condensing type and has the advantage of being fully as efficient with the flexibility for varying back pressures in case central station heating is adopted.

It is well known that but 15 per cent. of the total heat in steam is utilized in the prime movers before the steam is wasted in the condensers. Combined electric and heating properties such as the above are competing with hydro electric plants and showing much better returns.

COMPETENT ENGINEERING

The engineering features that surround a central station heating system are of such importance that the design, construction and installation should be taken care of by the best specialist obtainable. The difference in cost between the less efficient and the most efficient installations is very small compared with the returns on the investment of the best type, as the line loss on the poorer type is a vital point that must be taken into consideration. The best is none too good.

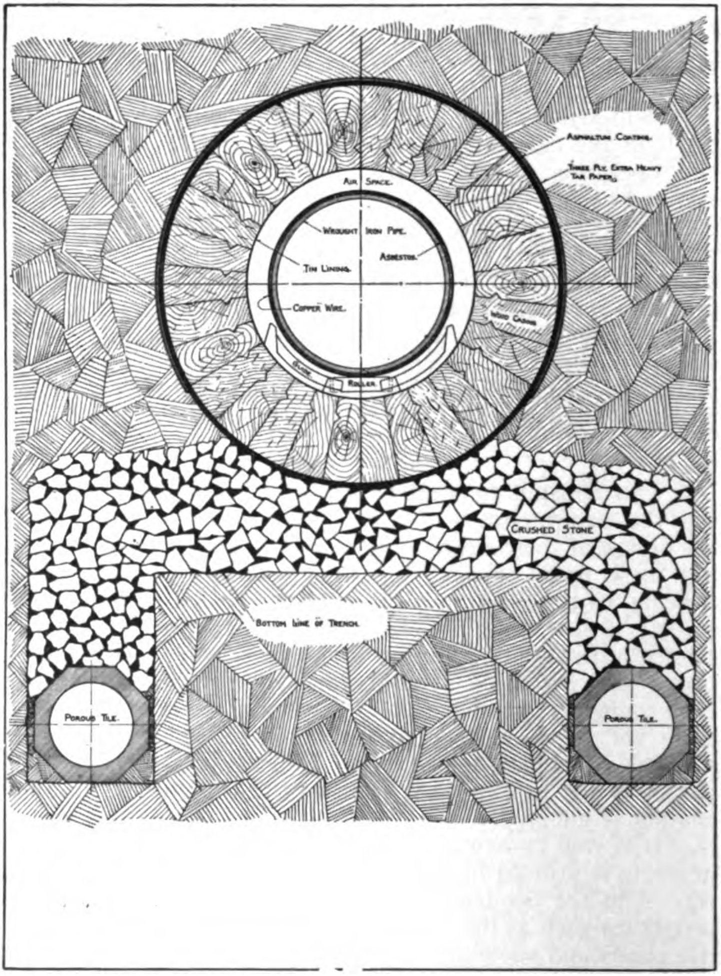


Fig. 1.

The once "slipshod" methods of underground construction of steam mains has proved unprofitable and today steam mains are being installed by proficient engineering corporations that guarantee their installation will prove satisfactory. The system of underground pipes should be encased in the most efficient as well as durable materials that the market affords, and it must be kept free from surrounding water by means of underdrain tile, Fig. 1. Joints of large size steam mains are welded into one homogenous length and installed across bridges and under flood water conditions. One engineering firm installed a steam main under tide water conditions. This later installation to the writer's notion is unique in that for three years the steam main has been surrounded with tide water and has never given any trouble. A brief description of this installation is as follows:

WATERPROOFING STEAM MAINS

The method of water proofing, described below, applies to fresh water conditions as well as tide water. However, tide water, due to its ebb and flow, is the cause of unusually difficult working conditions. Every twenty-four hours there are two ebb or low tides and two flood or high tides. These tides alternate first high then low, then high followed by low again. At the point where the waterproofing was done there was an eight and one-half foot tide. The average level of the water at high tide was only 29 inches blow the surface of the ground. At certain times in the month, unusually high tides prevailed and at these times the high tide level was often above the surface of the ground. All excavations had to be made on the ebb tide and all brick work had to be completed before high tide, six hours later.

The excavation for and building of manholes required more time than would elapse between high tides. To overcome this difficulty a type of coffer dam was built of brick and pitch. Excavation for manhole was carried on as tide level receded. When the desired bottom was reached, three-ply tar paper was laid on the bottom, the edges being overlapped slightly and pitched to make a joint. On this tar paper bottom hot pitch was poured and then bricks laid, flat side down, and pressed into the hot pitch. Over this brick bottom, pitch was poured to fill all spaces between brick. Four inch side walls were then laid by dipping ends and bottoms of brick in hot pitch and pressing the same firmly together in regular courses.

In this coffer dam of brick and pitch the masons laid the regular manhole with brick and Portland cement, regardness of the level of the incoming tide. For concrete work, a three-ply tar paper bottom was laid with edges turned up four inches on all sides and the joints were lapped a few inches and sealed with pitch. On this paper was placed a three inch concrete bottom. When this had set, another three-ply tar paper bottom was laid similar to the first. A thin layer of pitch between the concrete and tar paper held the paper firmly to the concrete. A one inch layer of pitch was poured on this paper bottom. This formed the base for side walls of brick box.

A one inch layer of pitch was poured between the layers of brick in the side walls, and likewise between the layers of brick which formed the top course. For such work it is necessary to use a type of pitch or asphalt filler that will not run under a temperature of less than 220 degrees F.

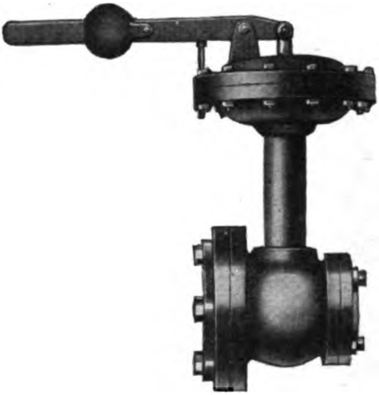


Fig. 2.

INTERIOR PIPING FOR ATMOSPHERIC HEATING.

The piping consists of a two pipe "flow and return" arrangement in which steam is circulated to all the radiators nnder pressures ranging below six ounces. Five to six ounces is sufficient for maximum demand, while less than this can be carried on milder days. A constant operating pressure is maintained on the heating system by means of a pressure reducing valve (Fig. 2) placed in the service main before connection is made to the supply piping in the building.

Steam passes into the top of the radiators, which are of the hot water type, through a graduated or fractional valve. (Fig. 3.) The area of the discharge opening of each valve is proportioned to the amount of surface on each radiation. A larger amount of radiating surface than is required for each room is provided so that each radiator furnishes its own economy coil whereby the condensed steam gives up a large portion of its sensible heat before passing into the return main. Thus, all the available heat contained in the steam and the condensate is radiated in the room where it is desired. As any portion of each radiator from the top down may be filled with steam according to the comfort of the occupant simply by manipulating the graduated valve, a great flexibility is secured that will meet any weather condition. This makes for economy, which is a very important fundamental from the viewpoint of the customer.

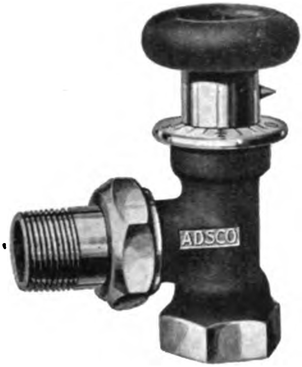


Fig. 3.

The reported failure of one or two central heating systems of old was due to the flat rate basis of charge and very poor management. Meter basis of charge has made electric light, gas and water plants successful. Too much emphasis cannot be placed upon this most important phase of the subject. The condensation steam meter is a very accurate device that has long passed through the experimental stage. Progressive central station heating companies test these meters periodically. The methed of testing is very simple and consists of a barrel or tank containing, say, 500 lbs. of water, mounted on scales. This water is fed to the meter to be tested at the rated capacity of the meter and when the barrel is empty the meter will show 500 lbs. plus or minus one or two per cent. Condensation meters are very accurate measuring devices and record as correctly as electric, gas or water meters.

MILLING AND FLOTATION.

By A. C. EMBSHOFF, '16.

The principles of hydraulic classification, e. i., the selective action exerted by a current of water upon a mass of sandy material composed of particles of different densities, have long been known. Hydraulic classification is most successful when applied to ores which do not slime easily, e. i., ores which are not readily reduced to an impalpable powder and from which the mineral is freed by comparatively coarse crushing. This type of ore fractures easily and contains the valuable constituent in the form of plates or crystals. The mineral in such ores, usually being much heavier than the gangue, is easily separated from the latter when subjected to the classifying effect of streams of water in the various concentrating machines, such as jigs, tables, classifiers, etc.

However, when the mineral is highly disseminated, it becomes necessary to reduce the ore to a very fine state of division in order to free the mineral constituent. It is mechanically impossible to do this without reducing a large portion of both the mineral and gangue to an impalpable powder or slime which is not succeptible to hydraulic classification. The reason for this is quite obvious. While it is true that the relative densities of the mineral and gangue remain the same regardless of the state of division, yet the water velocity required to move a particle of gangue is so nearly that required to move the mineral particle that is practically impossible to effect any separation of the two by hydraulic classification.

For many years these slimes were carried off with the waste and overflow water from the various machines used in concentrating the coarse mineral and often found their way to the tailings or waste dump. Several operators, however, believed that some day a commercial process would be discovered by which these tailings could be re-treated anda greater per cent. of the mineral recovered. This belief was justified when the flotation process was perfected.

The flotation process is especially successful in treating the product that evades concentration by water, namely, the slimed material. Advantage is taken of the fact that certain oils exhibit a marked affinity for the mineral particles in a mixture of mineral and gangue and comparatively no affinity for the gangue. Minerals having a metallic luster are especially susceptible to the process, whereas the carbonates and oxidized ores resist flotation until altered chemically or physically. The addition of sulphuric acid to the mixture of ore and oil appears to enhance the selective action of the oil for some minerals, notably lead and zinc. On the other hand, the addition of acid or an acid condition of the pulp is almost invariably fatal to the successful flotation of copper ores.

In the flotation process as practised today, the slimes from the hydraulic concentration are collected and sent to deviating tanks where the pulp solution is reduced to about 5:1, e. i., five parts of water to one of pulp or slime.

In the treatment of lead or zinc ores these slimes pass to sludge tanks where acid is added. From the sludge tanks the acidified pulp passes to an emulsifier. This machine is an air-tight cylindrical or square vessel provided with baffles and a rotating agitator blade having a peripheral velocity of 1,700 feet per minute. A very small quantity of oil is introduced with the pulp into this machine and thoroughly agitated with it. The amount of oil used is from 0.05 to 0. 1% of the weight of the dry pulp, i. e., one to two pounds of oil per ton of pulp.

From the emulsifier the mixture of ore, oil, acid, water, etc., passes to the flotation machine proper. This machine is usually similar in construction to the emulsifier except that air has free access to the interior of the machine, which is provided with a large box-like lip or "spitzkasten". In this machine the emulsified pulp is again violently agitated and large quantities of air are beaten into the pulp. As a result of this agitation, a froth is formed. The mineral particles float on this froth while the gangue sinks. When the portioning of ore, oil, acid, water, rate of agitation and rate of flow through the machine have been attained, the froth is very stable and persistent and is composed of thousands of tiny air bubbles, each bubble completely covered or armored with a coating of the slimed mineral.

The froth flows from the agitating compartment into the lip or "spitzkasten" previously mentioned, and while floating across the water in the "spitz" drops a large portion of the gangue that may have been picked up mechanically during agitation. The mineral frost then floats or is skimmed off the "spitz".

The cycle of operations just described is that of a single machine. In actual practice, one emulsifier serves a number of flotation machines. The flow of the pulp through the flotation plant will now be outlined.

From the emulsifiers the pulp passes to a set of flotation cells in multiple; that is, each cell receives its feed direct from the emulsifier. These cells are termed "multiple cells" or "roughers" and from them a froth, called the "rougher concentrate", is removed.

The waste material, or tails, from these "roughers" passes next to a set of cells arranged in series, that is, the tails from the first cell pass to the agitating compartment of the second cell and the tails from the second cell pass to the third cell and so on through the series of five or six cells. The froth removed from these cells carries some mineral and is termed a "middlings product" or "midds". The tails from the last cell in the series go to the tailings dump.

The rougher concentrate mentioned in a previous paragraph is sent to a set of cells in multiple known as the "cleaners" and the concentrate froth from these cells is sent to another set of multiple cells known as the "recleaners". From this last set the final product of cleaned concentrate is removed.

The tails or waste material from the cleaners and recleaners are combined with the "midds" from the series cells and returned to the head of flotation, where they are combined with the pulp that is about to enter the first set of "roughers".

A comparison of the relative efficiency of concentration by flotation and concentration by water may not be amiss. With flotation, tails containing only 0.5%:1.0% of mineral can be and are produced. With water concentration, tails seldom run less than 2% and in most cases run much higher, frequently carrying 7%:10% of the mineral. An extraction of 95%:97% is not uncommon where flotation is used, while an extraction of 60% is considered excellent in water concentration.

The flotation of copper ores differs in some respect from that of zinc and lead. The emulsifier is freqently dispensed with and the oil is added to the pulp as it enters the tube mills that do the fine grinding prerequisite to successful flotation.

One of the recent developments in flotation has been the entire elimination of the preliminary water concentration. At the Inspiration Consolidated Copper Company, Globe, Ariz., 18,000 tons of ore are treated daily and the ore from the mine is all reduced to suitable fineness and sent directly to flotation. Another unique feature of this installation is the hydraulic concentrators which follow the flotation machines instead of preceding them. In these concentrators the coarse mineral which escapes flotation is recovered.

The development of the flotation process was a big step forward in the conservation of our natural resources. It has made profitable mines out of low grade properties that were formerly considered impossible of development at a profit. It has made thousands of tons of tailings, considered at one time worse than useless because of the difficulty in disposing of them, susceptible of treatment at a handsome profit. Its application, whenever practicable, means increased extractions and lower operating costs; hence, higher efficiency. When the present dispute of litigation over the patent rights of flotation has been settled, we may look for a broader and more enlightened application of the process. Until then the secrecy observed by nearly all operators will be maintained and will prevent the frank interchange of opinions, observations and experiences so necessary to the elimination of duplication in research work and to the full development of a process so broadly applicable under widely divergent conditions.

DAMAGE TO OPERATING COMPANIES CAUSED BY LIGHTNING.

By Frank Scott, '16.

Lightning is a source of trouble throughout the year to companies that use or generate electrical energy. Continuity to serve is being demanded more and more by the consumer of electrical energy and the operating man must guarantee such service. It is needless to comment on the loss in time and money, to say nothing of the annoyance and inconvenience, caused when motors, transformer, lights, etc., are burned out during an electric storm. The writer intends in this article to make a study of the damage that was done to power companies by lightning, and if possible, to offer some suggestions for better protection.

Letters were sent to the pricipal Power and Railway Companies of Indiana, Ohio, Illinois, Michigan, Iowa, Minnesota, and Wisconsin asking for a report on the damage due to lightning during the year 1915. Forty per cent. of these companies replied.

The following questions were sent to the different electrical companies:

1. To what extent has your system been disturbed by lightning?
2. What apparatus has been damaged?
3. Has your trouble occurred in the same place more than once?
4. What protective apparatus was used, and where was it located with respect to apparatus damaged?
5. If possible state the cause, and give a brief description of the incident, including date.
6. If you have any further data or information, it will be greatly appreciated.

A survey of the damage due to lightning over the Northern central part of the United States shows that ninety per cent of the power companies have had trouble and when we consider that these companies are well distributed over this section, it is fair to assume that the figures given are representative of the damage to power companies in general.

Forty-five per cent. of these companies had their generative and distributive systems very seriously damaged; forty-two and one-half per cent., although not seriously damaged, were greatly inconvenienced by interruption of service and damage to equipment; five per cent. kept no record and seven and one-half per cent. had no trouble.

One-half of the ones having no trouble had underground systems.

APPARATUS DAMAGED.

Apparatus.	Per cent. of Companies that had trouble.	Per cent of particular trouble to total trouble.
Transformers	75	36
Meters	25	12
Insulators	17	8
Generators	15	7
Arresters	12	6
Oil switches	10	5
Lines	10	5
Poles	3	2
Fuses	10	5
Fuse blocks	12	6
Switchboard Instruments	5	4
Arc lamps	3	2
Incandescent lamps	3	2
Power House destroyed	3	2

The table shows that 75% of the companies had transformer trouble and that 36% of all damage can be charged to transformers. This high percentage is due to the fact that transformers are always connected directly to transmissions and distributing lines, and in the case of pole type transformers, they are exposed to cloud lightning as well as line surges. Furthermore, transformers, being connected directly to the overhead lines, are the first apparatus with which the lightning comes in contact, excepting lightning arresters which can not be considered with other apparatus, because they are especially designed to protect themselves as well as to give protection.

A further inspection of the table discloses the fact that meters are next with reference to extent of danger. Twenty-five per cent. of the companies had motor trouble, and this was twelve per cent. of all trouble recorded. In most cases the trouble was due to the burning out of meter shunts. This relatively large percentage of damage to meters can be accounted for as follows. First: Since there is such a large number of meters used in comparison with other electrical apparatus, it is reasonable to suppose that the relative number damaged would be great. Second: Meters are always placed on incoming or outgoing lines, a position which subjects them especially to lightning surges. Third: The mechanicm of the instrument must be of delicate construction, and consequently it is difficult to heavily insulate its parts.

Seventeen and one-half per cent. of the companies have had trouble with line insulators being broken. This represents eight per cent. of the total trouble, which does not seem unreasonable when we consider that insulators are in an exposed position, and are not protected.

Fifteen per cent. of the companies have had damage to their generators. This is perhaps a very fair estimate of damage to revolving machinery in general, because the generator is the most important and costly apparatus used, and no doubt all damage would be recorded.

The per cent of arresters damaged is comparatively large, because they are always placed so as to receive any abnormal surge before it reaches other apparatus.

The damage to the remaining apparatus listed is comparatively small. This is due not to the fact that less of this apparatus has been damaged but rather to the fact that damage was not recorded, because it did not directly interfere with service, and also the cost of fuses, lamp, poles, etc., seems relatively unimportant to the company when compared to the loss of a large generator or transformer.

The answer to the question as to whether the trouble occurred in the same place more than once, 50% of the companies answered "yes," 25% answered "no," and 25% gave no answer. A transmission line that crosses a place whose altitude is higher than the surrounding country, will be subject to repeated damage. In several cases it was found that the trouble was stopped by moving the apparatus only a short distance from its original position. One case in particular was that of a transformer which was burned up several times. It was finally removed two hundred feet from its original position with the result that no further annoyance was experienced. Lightning jumping from a heavy load in the vicinity was thought to have caused the trouble.

Some localities are more subject to disturbance than others, which can be attributed to two causes:

1st. The particular section may be of greater altitude than the surrounding country.

2nd. Due to dry, loose soil, it is difficult to get a good ground for the arresters. One engineer stated that their trouble was confined almost entirely to a section that was formerly swampy ground, and since the soil was composed wholly of decayed vegetable matter, it was almost impossible to get a ground for their arresters.

The arresters used were of the standard types, namely: choke coils and horn gaps, multigap, Garton & Daniels, D. C. arrester with magnetic blow-out, aluminum cell and overhead wires. The type or arresters that should be used depends upon the voltage and the kind of service and current delivered. The most trouble occurred where either too few arresters were used, or where they were improperly placed with reference to the apparatus to be protected. Arresters were formerly installed in a haphazard way. This was not due to any negligence on the part of the companies, but rather to the fact that correct methods of installation were not known. In many cases the arrester was placed at quite a distance from the apparatus to be protected, and there was a chance of lightning striking between the two, with the result that insufficient protection was secured. Arresters were placed in practically every case, at the power house, substations, ends of lines, and at regular intervals along the line.

Protection from a direct stroke of lightning is very difficult. The cost of protective apparatus, which can be depended upon in the case of direct stroke is so great as to make its use prohibitive.

Induced charges can be dissipated easily by the use of proper arresters. Reliable manufacturing companies make good arrestern which are adapted to nearly every kind of service, and in the installation of protective devices, the proper type of arrester for the particular kind of service should always be selected.

The question of proper location of arresters is an important one. Locating the arrester as near as possible to the apparatus to be protected seems to be the present tendency. Companies that follow this rule suffer the least damage.

A greater number of arresters could be used to advantage in many cases. They should be placed near to practically every piece of apparatus that is exposed to lightning. Economy must be considered in the installation of protective devices. It is not good policy to burden a system with arresters with the view of stopping all trouble. It is cheaper to have a line burn down occasionally than to have it completely protected. The cost of arresters as compared to other electrical apparatus is small; therefore in nearly every case, it is better to have too many than to have too few.

If possible the installation of apparatus such as transformers in elevated places should be avoided. When arresters are installed, good grounds should be made; otherwise the arrester can not perform its required duty. For the protection of three phase "Star" connected systems, grounded neutrals are very effective. Transformers are often installed as an insulation from lightning. The apparatus is protected because the transformer is between it and the lightning discharge, and the coils choke it back.

Arresters should not be condemned because they sometimes fail. It is remarkable that they perform their duty as well as they do, when we consider how peculiar lightning is in its behavior. When trouble occurs, the case should be carefully diagnosed by the engineer, and, generally, some change can be made which will prevent future trouble.

The following rules for the installation of lightning arresters contain many helpful and valuable suggestions.

1. The best arrester made is absolutely worthless unless it has a good ground. Perhaps the most essential thing to remember is that "Lightning arresters cannot have too good a ground."

2. STATION GROUNDS: Heavy copper or iron plates should be buried to such a depth that they are in damp soil the year round. If the plates are imbedded in carbon and occasionally wet, a good ground is always assured.

3. LINE GROUNDS: Iron pipes can be driven to such a depth that the lower end is always in the damp soil. When pipes are used, the wire from the arrester should be soldered at the top of the pipe, and not merely run down on the inside, for in this case the pipe acts as the short circuited secondary of a transformer and chokes back the flow of current to ground, which greatly decreases the efficiency of the arrester. Arresters that are inclosed in iron boxes tend to produce the same effect.

4. Short straight wires should go from the line to the arrester, and from the arrester to ground. All curls or twists should be avoided. If a turn is necessary, sharp angles should be avoided.

5. The air gaps should be kept clean and free from any foreign substance.

6. All joints should be carefully soldered.

7. Arresters should be installed at every station and substation, to protect the apparatus there situated.

8. Install arresters on the riser pole at risers, starting with the pot head, then choke coils, then disconnecting switches, then lightning arresters—all as near to the risers as possible.

9. Install arresters on the first pole outside of station where line leaves the station overhead.

10. Install arresters where the branch lines are tapped off.

11. Erect arresters at the crest of hills.

12. Install lightning arresters at every transformer of ten kilowatts or greater capacity.

13. Wherever lightning arresters are used, they should be connected to all primary lines, together with a

low voltage arrester on the neutral. All arresters should be installed on the same pole and connected to the same ground wire.

14. Lightning arresters should be placed on the same pole with the transformer or apparatus which they are to protect. This is imperative because of the oscillating nature of surges or lightning discharges.

15. Ground wires for arresters should be No. 6, and should be covered with moulding at least eight feet above the ground and six feet from the lower crossarm.

16. Install arresters on every electric car to prevent damage to the apparatus on the car.

STREET IMPROVEMENT PLANNING IN EDGEWORTH, PA.

BY E. A. BECK, '13.

The average small municipality appears to hold two erroneous views concerning street improvents; one, that a street pavement is a luxury, the other, that it is permanent, and a combination of the two is often responsible for results which prove a burden to the community for years to come. The effect of the first is usually that paving is delayed until forced by more than actual necessity and terminates in a type of improvement (adopted in many cases at the instance of abutting property owners who are frequently biased by the question of first cost and who in general are not competent to pass on such matters) which frequently proves unsuitable, unsatisfactory, extravagant in a broad sense, and forms a disturbing unit of a system of which it sooner or later becomes a part. The result of the second is even more detrimental. With a false sense of security in the belief that a pavement is a "permanent" improvement in the sense of duration instead of benefits from the advantages of a well improved and maintained highway, the feature of maintenance is neglected until it becomes a question of reconstruction. In brief, street paving is done with a fine disregard for the fundamental principles—improvements being made which bear silent yet continuous testimony to the lack of forethought connected with one of the most important features in the development of any community, resulting in a system of highways which are unsatisfactory to the traffic they serve and are a constant expense to those responsible for their maintenance.

In 1914 the Borough of Edgeworth presented a striking illustration of the outgrowth of conditions similar to the above. The street surfaces, roughly classified, consisted of the following: Brick, sand filler, on concrete base; macadam, slag aggregate, rock ashphalt binder, on slag base; macadam, limestone, rock ashphalt binder, on slag base; plain water-bound macadam, limestone; water-bound macadam on telford base; original sand or clay; creek gravel; slag.

The slag afforded a very interesting example of the result of conditions heretofore mentioned. Prior to the incorporation of the Borough in 1914, the community, by reason of its natural beauties, began to attract attention as desirable locations for suburban homes of Pittsburgh's business men. Something needed to be done to improve the condition of the existing dirt roads. Slag could be had for the freight charges and the Township authorities in charge of the District, whose powers and finances were limited so far as road improvements are concerned, saw a way toward "improvements" at a low cost. Holes were filled and the streets covered with slag, a coating of varying width and thickness being applied without regard to drainage, grades, or other conditions, the whole being compacted by traffic and in some cases by a horse-drawn roller, the intent being to furnish a "practical improvement", as expressed in Court by one of those originally in charge, when the question was tested as to whether or not this work constituted a street paving in the legal sense. However, the work provided relief from existing conditions to a certain extent and proved very satisfactory for the time being.

The brick, rock ashphalt and plain macadam were laid within the conforming to prescribed lines and grades. The telford macadam, which was laid by the County prior to these latter, followed the lines of least resistance; both grades and lines were ignored, the lines in no respect conforming to the street boundaries.

The slag, however, furnished the strongest example of the extravagence of a so-called economical improvement. Subjected to changes in traffic conditions, which work or this nature cannot and is not intended to withstand, the effects soon became apparent, and the Borough's funds were annually expended in profitless maintenance to the neglect of the better improvements. The result was that in 1914 all of the highways were in equally bad condition with no prospect of betterment, and this in spite of a conscientious expenditure of all available revenues for that purpose. Facing the situation squarely, the Borough Council abandoned the former policy and inaugurated a program along advanced lines. A survey of the entire situation was made and the following facts developed:— That the slag streets were not a subject for repairs but of construction; that the telford macadam was unsuited for the particular traffic it had to serve and renewal in kind was therefore unwise; that the other types of macadam and also the brick could be made to provide saisfactory service for some time to come by proper maintenance; that the earth and gravel roads were cheap only in dollars and cents and costly in terms of annoyance, inconvenience, etc. The popular view concerning street pavements was changed, street improvements were decided to be a necessity instead of a luxury, and when physically applied, the only "permanent" feature being the repairs. By eliminating useless repairs, a classification of the estimated revenues and expenditures of the Borough revealed sufficient balances to adopt a regular street maintenance plan and in addition provide an annual fund sufficient to cover approximately $30,000.00 worth of new paving.

The brick street maintenance expense was brought about by slides and direct lack of drainage, and which was remedied, reducing the following three years' maintenance expense to nothing on that street. The macadam maintenance program provided for complete treatment of each street as a whole, biennially or triennially, as the conditions of each individually seemed to warrant, the streets being grouped so that the annual expenditure would remain about constant. In general, in addition to repairs, this treatment consisted of a bituminous carpet treatment, the technical features of which are too extensive to detail in an article of thiss character. Suffice it to say that the principal street so treated has been in service the estimated period without expense and appears to be in condition to furnish an additional year's service.

The estimated improvement funds were deemed sufficient to adopt an improvement program which would result in paving the unimproved streets within the following five years and with the maintenance policy adopted would deliver to the Borough at the end of that period 100% of its streets improved and in first-class condition. The success to date may be judged by there now being 75% of the mileage paved and in good condition, a little ahead of the program.

On all new construction an effort was made to standardize in every possible respect these same standards being adopted in part or to as great an extent as real economy permitted on reconstruction. Anticipating the necessity for a variation in the character of surfaces, two types were adopted for all work, brick and asphaltic concrete, each possessing individual characteristics particularly applicable for the streets for which the same were selected. These two were selected after a careful study of the various popular tyes, especially with reference to present and probable local traffic conditions, and the selection was made principally from a standpoint of "service," i. e., the ratio of duration to cost together with satisfaction during the period of duration. The results of experience were deemed sufficiently well established and conclusive to permit a safe estimate of the probable duration of any particular type of present-day pavement under certain traffic conditions. Satisfaction during duration is dependent upon many factors, but in this particular Borough hinged on the sanitary and aesthetic. It follows that the problem became more or less a ratio of duration to cost, or briefly, economy, comparative results being obtained by the application of the following formula:— The initial cost plus a sufficient additional sum which at 5% compound would cover the estimated maintenance during probable duration, divided by the estimated period of duration. The brick, while more economical in most cases by this comparison, was objectionable for certain streets for aesthetic reasons, and in these cases satisfaction became the determining factor, which, after all, when applied to community life in all its phases, is the prime incentive for the establishment of municipal corporations.

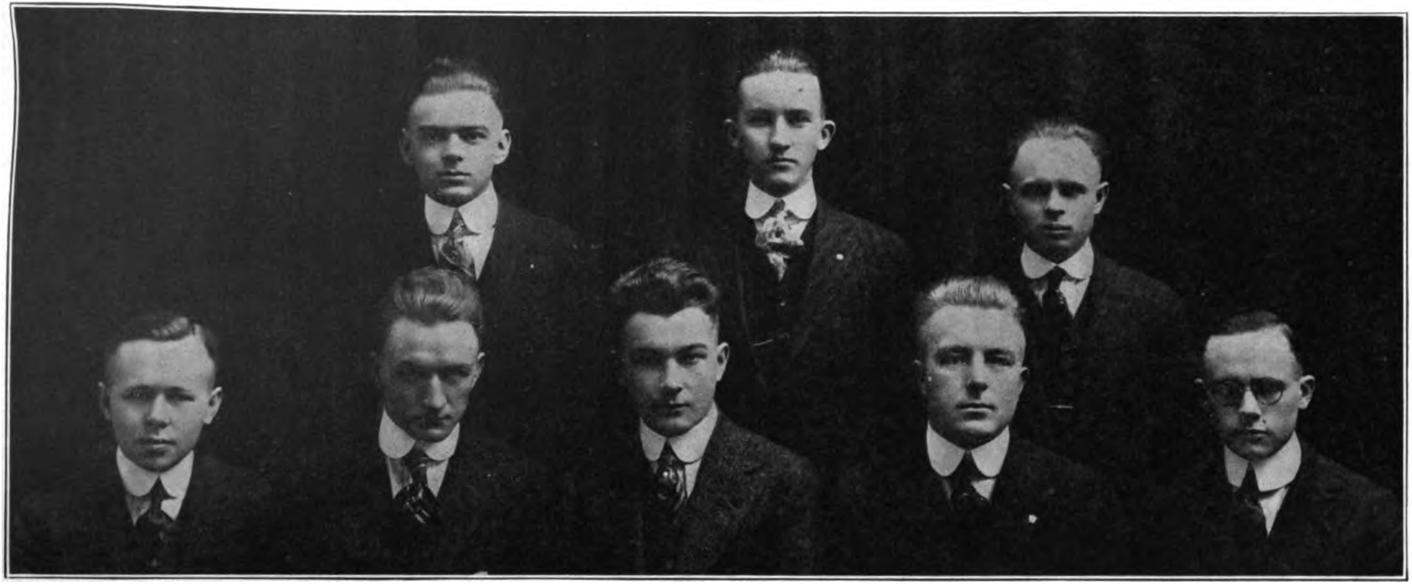
With the general program adopted so far as construction was concerned, each street was considered individually, careful consideration being given the present and probable traffic, the character of present and probable residences, the surroundings, the future development of abutting land, etc., and the improvement made to harmonize therewith without sacrificing any essential construction features. Grades were established with particular reference to abutting property and in some cases where unavoidable cuts would detract from nature's beauties, the sidewalk grades were elevated; a turf terrace between the walk and street pavements giving an individual touch to the entire improvement.

The cartway was made the minimum estimated sufficient for the probable traffic during the life of the pavement. It is of interest in this connection to note that the difference in cost between pavements of the widths in the ratio of 1 to 1½, plus 5% compound for a 15-year period at prevailing local costs, will resurface in kind the former and in addition cover the cost of increasing same to the latter.

Where storm drainage and traffic permitted, curbs were reduced to a height of three inches except at street intersections, and with the sidewalk at a higher elevation permitted an attractive treatment of the parkway.

On all streets provision is being made for the eventual removal of all overhead service lines and the installation of ornamental electric lighting standards, and which has been completed to the extent of about three miles. Effort is made to preserve the individuality of each street.

While the practical features of improvements have been given careful consideration, the question of attractiveness has been kept in mind to such an extent that the completed work is believed to represent a combination of the two without detriment to either.



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W. W. WENTZ. H. J. BIDDLE. N. E. HULL. O. W. KASTENS. R. A. HAYWORTH

The Purdue Engineering Review

No. 13 PURDUE UNIVERSITY MAY, 1917

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ENGINEERING EXPERIMENT STATION.

Purdue University may soon claim an Engineering Experiment Station. The Board of Trustees on February 28 approved the organization of such an institution, the function of which shall be "to conduct research in the field of engineering, to co-operate with engineering societies in conducting industrial investigation, and to publish and distribute the results of such investigations in the form of bulletins or otherwise as may seem desirable. The heads of the engineering schools, together with the Dean of Engineering, are to constitute the Board of Management of the Experiment Station which shall determine all questions of policy, designate the lines of research to be undertaken, and formulate a plan of operation." An annual budget providing for necessary funds to carry on operations of the Station will be submitted.

Department Notes

SCHOOL OF CIVIL ENGINEERING.

RESEARCH.

A number of investigations have been in progress in the Laboratories for Testing Materials, and Hydraulics, during the past year, some of which are tests of various types of metal lath, tests of rolled sheet iron metal lumber, extensive research upon the effect of Hydrated Lime admixtures upon the strength and density of concrete, investigation as to the bonding strength between brick and mortars, tests upon the loss of head in spirally riveted steel pipe from 4″ up to 10″ in diameter, and investigation of the loss of head through bends, valves and other fittings.

A test upon a full sized flat slab floor, invented by Edward Smulski, of Boston, was made on the campus, for which a panel 40 foot square supported on nine columns was erected. Eight car loads of brick were used as loading material.

NEW EQUIPMENT.

The Laboratory for Testing Materials has recently installed a standard machine for testing toughness of stone. Professor Scofield has developed an abrasion test for gravel intended for use in roads.

The Trustees recently voted an appropriation for the construction of a one million pound testing machine. This will enable the Laboratory for Testing Materials to engage in some of the large investigations of building material.

STATE SERVICE.

Over one hundred road officials were in attendance at the annual Road School held June 16-18. A series of county road schools were held in February under the direction of the Highway Department.

Professor Hatt was a member of the Board of State Directors of the Naval Consulting Board which made an industrial survey of Indiana for military preparedness.

GENERAL.

The freshman class this year is nearly 50% larger than that of last year.

An elective course in Reinforced Concrete Engineering was offered for the first time during the past year. A course in Architectural Engineering has been devised and may be established in the near future.

The department has had a large number of inquiries for men having some engineering experience. The office is now compiling a complete list of graduates and experience in order that future inquiries may be taken care of.

The new appointments to the instructional corps were C. L. Gray, '12, and M. J. Stinchfield, '16, as assistants in the Testing Laboratory.

SCHOOL OF CHEMICAL ENGINEERING.

The steady growth of this school continues, in spite of the heavy curriculum. A growing demand for graduates is evident and promotion has been rapid.

The curriculum has been improved during the present year by permitting members of the senior class to substitute Physical Chemistry for Thesis, thus affording additional opportunity for training in this important line.

One of the notable features of the year, constituting a recognition of the standing of the University in the field of Chemistry, was the establishment of a chapter of the honor fraternity, Phi Lambda Upsilon.

The establishment of the Engineering Experiment Station should in time prove highly beneficial in permitting this school to assist the manufacturing interests of the State in the solution of some of their problems.

SCHOOL OF ELECTRICAL ENGINEERING.

PERSONNEL.

Mr. R. V. Achatz, who has had charge of the work in Telephone Engineering of the School of Electrical Engineering for a number of years, has been advanced tc the rank of Assistant Professor of Telephone Engineering. He is devoting much of his time to the course in Corporate Organizations which is now required of all seniors in the School of Electrical Engineering. Messrs. L. D. Rowell and D. D. Ewing have been made Associate Professors of Electrical Enigneering. Mr. L. L. Bouton, who has been Assistant in the School for two years, and who completed his graduate work with the degree of E. E., has resigned during the year to take up research work with the A. T. T. Company of New York.

NEW HIGH VOLTAGE LABORATORY.

As a result of recent action of the Board of Trustees, plans are being made for a new high voltage laboratory involving a testing transformer which will provide test voltage up to 500,000 volts. This transformer, together with auxiliary control equipment and extra high voltage measuring devices will be installed in an extension to the Electrical Building, to be provided during the coming year.

RESEARCH.

Research investigations have been undertaken in connection with the fixation of atmospheric nitrogen by the silent electric discharge method at high voltages. It is expected that this particular process may offer some interesting information in connection with the production of nitrates which are so much in demand at the present time. A comparative study is also being made of the relative efficiencies and operating costs of gas and electric ranges for household cooking with different rates charged for electrical energy.

Traffic studies in connection with local street railway systems, together with those in Toledo, Ohio, and Indianapolis, Indiana, are being made as well as a number of investigations in connection with rolling stock equipment.

SCHOOL OF MECHANICAL ENGINEERING.

During the year this school has had the use of $1,500 worth of valuable apparatus for carrying on thesis work and research problems. New equipment to the value of $2,600 has been added to the equipment. Over $500.00 worth of equipment and material for exhibit or routine laboratory work has been received from friends of the institution.

Forty-nine lines of research have been carried on under the direction of members of the teaching staff. Eleven articles have been published in engineering journals and proceedings of engineering societies on subjects of interest, while three sets of instructional notes have been printed for use in this institution.

RESIGNATIONS.

Mr. F. C. Goldsmith, Instructor in Machine Design, to become Chief Engineer of the Davis Sewing Machine Company, Dayton, O.

Mr. H. S. Dickerson, Professor of Mechanical Engineering, to become Head of Department of Mechanical Engineering, Missouri School of Mines, Rolla.

Mr. W. H. Severns, Assistant in Mechanical Engineering, to become Assistant Professor at the University of New Hampshire.

NEW APPOINTMENTS.

H. B. Ensign, B. S., Purdue, 1914, Instructor in Machine Design, and J. E. Hannum, Instructor in Mechanical Engineering, Pennsylvania State College, now Instructor in Industrial Design and Engineering Laboratory.

INCREASE OF TITLE.

Mr. A. R. Nottingham, Instructor in Mechanical Engineering, has been made Assistant Professor of Experimental Engineering.

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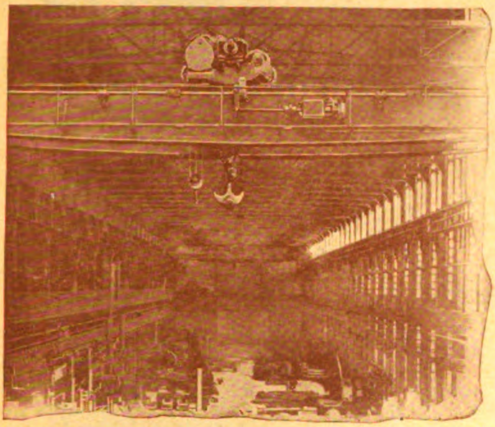

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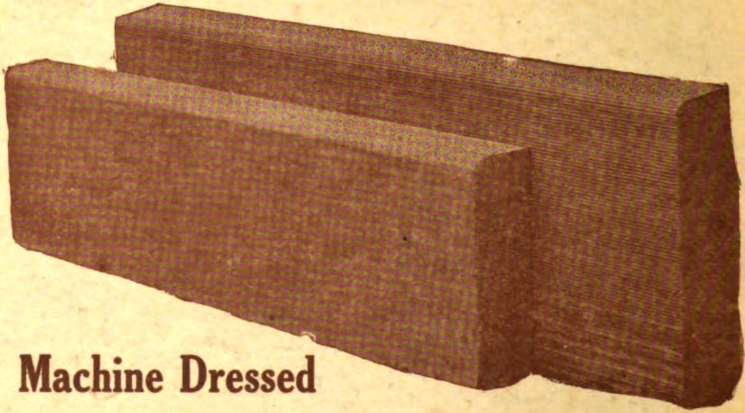

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The Purdue ENGINEERING REVIEW

PURDUE UNIVERSITY
1918

No. 14 **MAY 1918**

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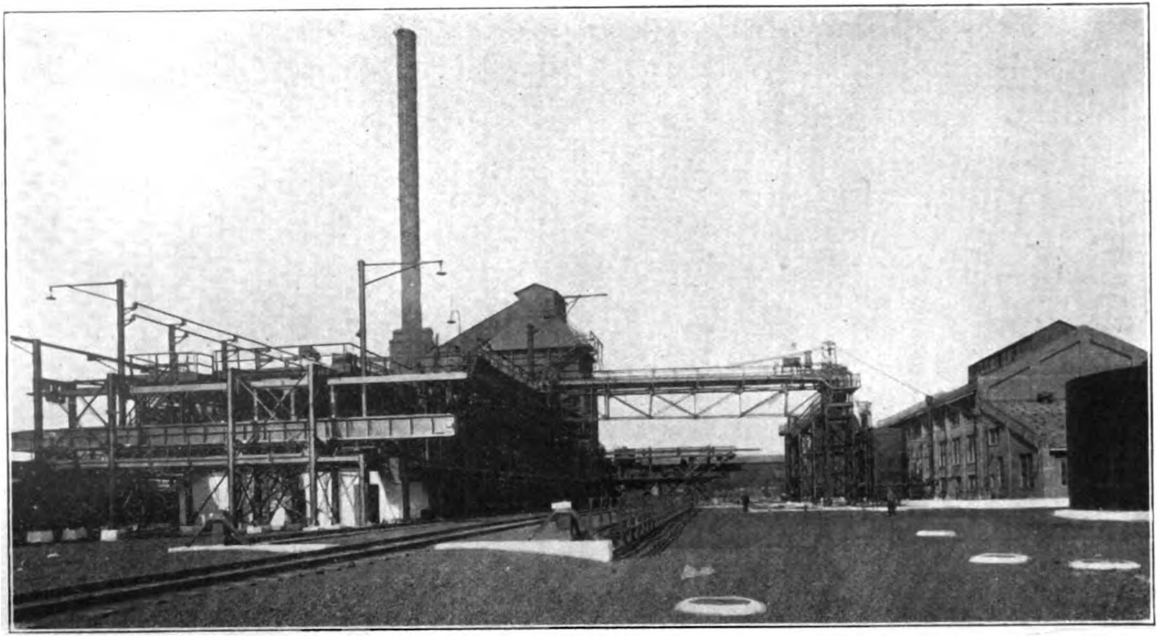

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No. 14 PURDUE UNIVERSITY 1917-1918

RECOVERY OF BY-PRODUCTS FROM BITUMINOUS COAL

By E. C. PLANK, '10

It is not intended that this discussion of By-Product recovery from coal should be of a highly technical nature. Neither is it the desire of the writer to claim any extended original research, but rather to describe briefly the operation of a modern By-Product Coke Plant, and perhaps at the same time to point out a few factors necessary to efficient operation that in many cases are apparently neglected.

The plant referred to above is that of the Gulf States Steel Company, at their Alabama City, Ala., works. It was built in 1916 by the H. Koppers Company of Pittsburgh, Pa., and began operation April 1, 1917. In design and equipment it represents the best known to the builders at the time of its completion and applicable to a plant of its size. It consists of 37 Koppers, cross regenerative type rectangular ovens, the walls of which are made of high grade silica brick. These oven chambers measure approximately 37 feet in length, 10 feet in height, and taper in width from 17 inches at the narrow end to 19½ inches at the wide end.

The ovens are separated from one another by a series of vertical flues in which the fuel gas is burned to provide the heat necessary for coking the coal. Directly under each oven chamber is an individual regenerator where the air for combustion in the flues is preheated, and directly beneath each row of flues is a solid brick wall separating the regenerators. This wall serves as a strong foundation on which the flue walls rest as columns to support the roof of the ovens. Since the flue walls themselves are strongly built, this form of construction combines strength with saving of space, since intervening walls to support the oven roof are eliminated, and the distance from center to center of the ovens is reduced to a minimum.

In the top of each oven chamber there are five openings. One at the extreme end of the oven provides an outlet for the gas. The other four are for charging the coal.

The Koppers oven is noted for the simplicity and positiveness of its heat control. Each flue may be inspected so that any tendency to local overheating may be corrected immediately; uniformity of heating and uniformity in the quality of the coke are thus insured. The available capacity for coal is about 500 cubic feet, or approximately 13 tons. This charge of 13 tons yields, on the average, about ten tons of Furnace Coke, used at the Blast Furnaces, and less than a ton of breeze (fine coke) used under the boilers as fuel. The yield of by-products approrximates the following:

For every ton of coal charged there is produced 7½ gallons of tar, 22 pounds of ammonium sulphate (or in terms of NH_3 about 5½ pounds), 7000 cubic feet of surplus gas of 525 B.t.u., and about 2.5 gallons of crude light oil (the percent of volatile matter in the coals used being approximately 25.00). From this light oil is obtained by refining about 1.25 gallons C.P. Benzol, 0.30 gallons C.P. Toluol, and varying amounts of Solvent Naphtha, Xylol and Napthalene.

The usual coking time is 16 hours and 30 minutes "net," or 17 hours gross. The coal used is an Alabama coal mined at Virginia City, and is very clean, jet black, soft and friable, and possesses excellent coking qualities. On account of its superior coking properties, it was used alone, even though the percentage of volatile matter was comparatively low. The coal bed in which Virginia coal is found is the Pratt in the Warrior Field, Carboniferous age, Pottsville group, and is very similar to the coal from the Dolomite Mine described on page 339 in Bulletin No. 22, Bureau of Mines. A representative analysis of the coal is:

Moisture	2.21
Volatile matter	24.60
Fixed carbon	68.53
Ash	6.32
Sulphur	1.06

The coke produced from Virginia coal is a high grade metallurgical coke, and is used in the Blast Furnaces, the reresults obtained there being very satisfactory and superior to any bee-hive coke used in the past. It is very firm, dense, and uniform in structure, the minimum amount of cross fracturing being due to the small amount of slate present in the coal. The analysis varied but slightly from day to day, and is represented by the following:

Moisture	2.47
Volatile matter	0.90
Fixed carbon	90.02
Ash	9.31
Sulphur	0.92

Shatter test....76% above 2″ (24 ft. drop)

The excellent results of the plant as a "coke" plant are made possible by the almost positive control of the heating system. Daily attention is given to minimizing any air leakage between the heating flues themselves, as well as between the heating flues and the coking chamber. Due to this care, as well as to the design of the ovens, we are able to maintain an even and uniform distribution of heat throughout the entire oven. Consequently, the coke is of uniform quality and structure. This exceptional control of oven temperatures not only has made it possible to produce a maximum yield of good furnace coke, but has had a decided bearing upon the quality and amount of by-products.

The coal is unloaded from cars into a track hopper, on to a belt conveyor which elevates it into the crusher building, where it first passes through a rotary screen (Bradford Cleaner). In this Bradford Cleaner all slate, bone coal and foreign matter, such as mine car links, mule shoes, miscellaneous wood, metal objects, etc., are removed from the coal. Any large lumps of coal too hard to break up and pass through the screen pass out with the refuse from the Bradford.

From the Bradford Cleaner the coal passes into a hammer mill, which crushes it so that at least 80 per cent will pass through a ⅛-inch mesh screen. The crushed coal is carried by a belt conveyor into a bin or bunker located above the battery of ovens. From the bunker it is loaded into a charging car, weighed accurately on a standard railroad track scale, and at regular intervals is charged into the oven chambers. The oven chamber is then sealed as nearly air-tight as possible. The gas produced is led by a "stand-pipe" or "off-take" into the "collecting main," which receives the gas from the entire battery of ovens. From this "collecting main" the gas is drawn by exhausters located in the "By-Product" house.

Located near the ovens is a pressue regulator, operated electrically, of the "Northwestern Automatic Governor" type, maintaining a uniform pressure of about two millimeters, water pressure, on the collecting main. Between the "collecting main" and the By-Product building is a set of tubular water coolers, the gas passing around the tubes and the water through the tubes, counter current to the flow of water. At the inlet to the Primary Coolers, the temperature of the gas is about 100° C., and at the outlet it is approximately 20° C. During the passage through the coolers, water and NH_3 vapors, together with those of a portion of the tar, condense and drain into the "Hot Drain," a tank being provided for that purpose. The gas then travels through the "Exhauster," which pulls the gas from the ovens, through the mains and coolers, and is then forced through the remaining apparatus. It is first forced through the "Tar Extractor," where several perforated baffle plates cause the particles of tar remaining in the gas to collect and drain by gravity through a series of seals into the "Hot Drain Tank."

A portion of the mixture of tar and NH_3 condensate (weak ammonia liquor) in the Hot Drain Tank is circulated through the oven gas collecting main in order to cool the gas, to prevent the formation of pitch and to keep all of the pipes and channels clean and open, while the remainder of this mixture is pumped into a "Tar and Ammonia Separating Tank," where the tar and ammonia liquor separate by gravity (decantation), the tar flowing into the Tar Storage Tanks, ready for shipment.

According to H. Koppers, the effective removal of tar from the gas cannot well be done by mechanical means only, and cooling of the gas is necessary. Having thus freed the gas from tar, it is possible to bring the dew point of the gas to a temperature low enough for good results in the saturator, where the NH_3 vapors react with the sulphuric acid in the usual manner, and, on account of the dew point being brought to such a low temperature, the acid bath in the saturator is not diluted seriously by the moisture carried in the gas.

From the "Tar Extractor" the gas passes into the "Reheater," where the temperature is raised and held almost constantly at about 50° C. It is then forced through the saturator with its bath of sulphuric acid. The strength of this bath is maintained at approximately 7.00% H_2SO_4. The saturator throws a back pressure of about 25" (water).

The weak ammonia liquor which condenses from the gas during its travel from the ovens and through the Primary Coolers is passed through a still where the ammonia is driven off, the NH_3 vapors entering the oven gas main just before the saturator, and are converted into ammonium sulphate. Thus, the Koppers system of recovering ammonia from the gas is the so-called "Semi-direct."

The gas leaving the saturators passes into the "Final Coolers," where the direct application of water, during the cool months of the year, cools the gas to 20° C., or less. This sudden cooling of approximately 25° to 35° causes the major portion of the napthalene to drop out in the coolers.

From here the gas passes into the "Scrubbers," which are cylindrical tanks 10 feet in diameter by 75 feet high, and filled with wooden grids placed so as to give a maximum amount of surface exposure. The gas enters at the bottom of the scrubber and travels upward, meeting a spray of petroleum oil entering at the top, the gas and oil traveling counter current. This oil, known as "Wash" or "Absorbent Oil," has the quality of absorbing from the gas the crude "Light Oil," which is a trade name for a mixture of Benzol, Toluol, and other homologues such as Xylol and Solvent Naptha. When the gas finally leaves the last scrubber, all of the tar, ammonia and light oil have been removed. It then travels to the gas holder, from which a part returns to the ovens, where it is burned in the heating flues to coke fresh charges of coal, while the surplus is sent to the Steel Plant, where it is used in heating billets, burning dolomite, firing steam boilers, etc.

The "Wash" or "Absorbent Oil" used in absorbing the Light Oil from the gas is a petroleum product usually known as "Straw Oil," of which at least 90 per cent should distil between 250 and 300 degrees centigrade. We have obtained the best results from Straw Oil, the specific gravity of which was less than 0.88 at 15° Cent. and which was readily fluid at 4° Cent. It should contain no Napthalene or pitch, and must have a good solvent action on benzols.

The Wash Oil, after having circulated through the scrubbers, is saturated with Light Oil and is termed "Benzolized Wash Oil." The gas entering the scrubbers is termed "Benzolized Gas," and that leaving the scrubbers is called "Debenzolized Gas." The Benzolized Wash Oil flows by gravity into the Benzolized Wash Oil tank, whence it is pumped through a heat exchanger where its temperature is raised to about 40° C. It then travels through a second heat exchanger, where the temperature is raised to about 75° C. From this it passes through a superheater and enters the "Light Oil Still" at a temperature of approximately 150° C. In the first heat exchanger the Benzolized Wash Oil is heated by the hot vapors leaving the Wash Oil Still. In the second heat exchanger—"Oil to Oil"—the oil is heated still higher by hot oil leaving the Wash Oil Still. The Wash Oil Still is composed of a series of superimposed sections or chambers, as in common distillation practice. The heated oil flows down through these sections while steam is blown directly into the lowest section and travels in a direction opposite to that of the oil. The mixture of Benzol and water vapor is partially rectified in the upper partition of the still and then enters the "Oil to Vapor" heat exchanger, as mentioned before, where it is condensed and the preheating of the Benzolized Oil is affected. The remaining vapors are completely condensed and the total condensate cooled in a water cooled condenser. The Light Oil is separated from the water in the condensate by means of a separator (continuous decanter).

The Debenzolized Wash Oil, after leaving the still, passes through the "Oil to Oil" heat exchanger, where it gives up a portion of its heat to the Benzolized Wash Oil. It is further cooled in water coolers, the oil being inside the coils and flowing water on the outside. The cooled oil is then pumped again to the scrubbers, thus completing the cycle.

In the earlier Benzol Plants the heating and cooling were not at all economical, but recent installations show decided improvements in these respects. In fact, there does not seem to be a great deal of room to improve upon the economy of heat in the cycle of gas treatment, distillation and cooling, through which the oil passes. (See "Recovery of Benzol from Gas," by F. W. Sperr, Jr., Chemist, H. Koppers Company.)

In the Koppers system it is calculated that the devices for heat economy reduce the steam consumption in distilling the enriched or Benzolized Wash Oil by more than 80 per cent. One thousand gallons of enriched oil 77 to 284 degrees Fahr. (1000 × 7.3 × .537 × 2.7) gives 811,440 B.t.u., corresponding to 840 lbs. steam at full pressure, or per 1000 gal. purified benzols, 55 × 840 = 46,200 lbs. of steam, which, at two cents per 100 lbs., costs $9.24; of this steam, the "Oil to Oil" heat exchanger cooling the hot debenzolized oil from 275 to 170 deg. Fahr. in preheating the enriched oil saves per 100 gals. enriched (973 gal. debenzolized oil) 973 × 7.3 × 54 × 105 = 402,675 B.t.u., or 417 lbs. steam, or 49.8 per cent of the total; the "Oil to Vapor" heat exchanger heating the cold, enriched oil by the benzol vapors and setam from the still, adds a recovery of about 256,000 B.t.u. per 1,000 gallons of wash oil, equivalent to 265 lbs. of steam, or 31.5 per cent of the total; in the two heat exchangers, therefore, the total saving is 417 + 265 = 682 lbs. of steam per 1,000 gallons of enriched wash oil circulated, or 37,510 lbs. of steam for every 1000 gallons of purified benzols produced, and the cost of steam for this purpose is reduced from $9.42 to $1.72 per 1,000 gallons of product. ("Recovery of Benzol from Gas," by F. W. Sperr, Jr., Chemist, H. Koppers Company.)

"Further economy lies in the saving of cooling water circulation that would be required to cool the debenzolized Wash Oil." ("Recovery of Benzol from Gas," by F. W. Sperr, Jr., Chief Chemist, H. Koppers Company.)

The light oil flows from the decanter to storage tanks provided for the same. From here it is pumped into what is known as the "Crude Still," similar in some respects to the Light Oil Still. The light oil is separated into crude fractions, preliminary to washing and final purification.

This, and subsequent distillations, are made intermittently in stills of large capacity (6,000 to 12,000 gal.), which give better fractionations than are possible in smaller apparatus. The continuous type of still has not been found satisfactory in this work. The crude still does not require the elaborate dephlegmator that is necessary on the final rectifying stills. The heating is accomplished by means of internal steam coils and a direct steam spray. The Benzol and Toluol are principally distilled off by indirect heat, using the steam coils, and the higher boiling constituents, Xylol, Solvent Naptha, etc., are then distilled over by introducing steam directly into the still.

After the Benzol, Toluol, Xylol and Solvent Naptha have distilled off, a certain amount of Wash Oil containing Napthalene remains in the Crude Still Tank. The presence of Wash Oil is due not only to mechanical trapping of the heavy oil during the distillation, but also to the actual distillation of some of its original constituents by agency of the direct steam used.

The Wash Oil from the Crude Still is drained into a cooling pan, where it is cooled in the air to crystallize out the Napthalene. It is then drained back into the circulating tank to be used again on the scrubbers.

There are several systems of fractionating the light oil into crude portions. The two systems most frequently found are:

First—That recommended by the research laboratory of the "Barrett Company," who handle a large proportion of the coal tar products made in the United States. According to this method the distillation is carried on thus:

Up to 80° C.—Fore-runnings.
*30% at 100° C.—Crude Benzol.
*30% at 130° C.—Crude Toluol.
*30% at 160° C.—Crude Solvent Naptha.
205° to 210° C—Crude Heavy Solvent Naptha.
Residue—Wash Oil and Napthalene.

***These distillates are sampled by catching a "snap" portion from the condensate stream as it leaves the condenser.**

Second—That recommended by H. Koppers Company.

In this system of crude fractionation, two fractions are made, the first, or "Crude First Fraction," the stream test of which at the close of the fraction shows approximately 30% at 160° C., and the second fraction, "Crude Second Fraction," which contains everything above the "Crude First" excepting the residue left in the still, and which, like the residue left by the Barrett method, consists of Wash Oil and Crude Napthalene.

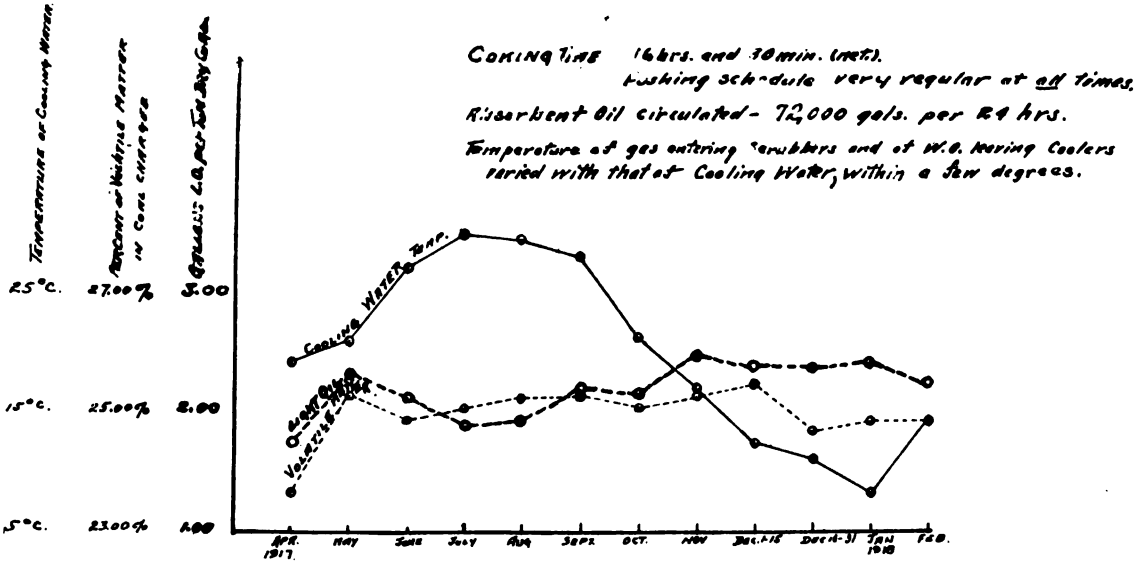
A choice of the above methods of Crude Still operation depends largely upon the nature of the Light Oil produced, and also upon the facilities provided for the storage of the products. In some plants it has been found that the "Two Fraction" or "Koppers" method is objectionable on account of the difficulty of washing the "Crude First Fraction." This, however, depends largely upon the nature of the coal charged. In the coking of practically all coals it has been found that the condensable hydro-carbon vapors belong almost entirely to the aromatic series. Benzol, together with its homologues, Toluol and the Xylols, constitute over 85%. Other substances present in much smaller amounts are carbon disulphide, thiophene, pyridine, napthalene, and various olefines of both cyclic and open chain structure. Members of the paraffin series of hydro-carbons are almost entirely absent. The mode of formation of these compounds in the destructive distillation of coal, the effect of various conditions of carbonization, such as temperature and rate of heating, on the character of the various substances formed, and the variation in the quality and quantity of the products from different coals are subjects of extreme interest, but which do not seem to be very well understood. However, it is generally found that the higher the percentage of compounds above Toluol, the more difficult is the "washing."

In the Plant of the Gulf State Steel Company the Koppers method has been used, and so far no difficulties due to the method have been encountered.

The Crude First Fraction is charged into an agitator where small amounts of commercial sulphuric acid—66° Be—are added to the crude product. After each addition of acid the charge is agitated thoroughly. The acid and crude product being thus brought into intimate contact, the acid polymerizes most of the impurities, which consist of various olefines and substances of similar character, together with certain phenoloid bodies. This results in the formation of resinous substances of high boiling point, part of which are insoluble in the Benzols and settle out with the acid in the bottom of the agitator, while part go into solution, giving the Benzol a dark brown or reddish color. The acid sludge is drawn off. Caustic Soda is then added, in order to remove some phenoloid bodies and chiefly to neutralize any traces of acid. It has proven best to wash with water after the last acid wash, since this removes a portion of the remaining acid and thus effects an economy in the amount of soda required. The final product—"Washed First Fraction"—contains all of the Benzol, Toluol, Xylols, and Solvent Naptha (light). This product is then distilled in another so-called "Pure Still," where the dephlegmation is very efficient. The fractionation here is so well regulated and controlled that the "cuts" are remarkably close and the percentage of "intermediate" or "re-run" fractions are exceedingly small.

The pure benzol and pure toluol are of such a grade that in the case of benzol the entire distillation range, from "First Drop" to "Dry," has been known to be as small as 1.2° C., and 95 per cent distilling within 0.3° Cent. On toluol the total range has been as low as 1.3° C. and 95 per cent within 0.4° Cent. Such a degree of purity of products is due largely to the improved design of the dephlegmators on the newer refining stills.

In the designing and laying out of this coke plant, the builder omitted nothing applicable to an installation as small as this that could count for efficiency in By-Product recovery, in so far as mechanical equipment was concerned. There is probably no coke plant built previous to 1917 that so nearly represents the ideal as does this one. It was modeled after the plant which at that time (1916) was considered by Koppers Company to be their best, excepting that certain features were here added which were considered superior even to that in their model plant. The battery of ovens is unquestionably one of the finest in the country. The heat regulation is almost perfect and thoroughly flexible. The design and workmanship in the By-Product Department, where the tar and ammonia are recovered, the latter as sulphate of ammonia, is very good. The benzol equipment and apparatus is well designed and, while not so elaborate as that in some of the larger plants, yet it is efficient and has proven to be capable of most desirable results. As stated before, the steam economy in the Benzol Department is remarkable. The facilities for cooling both the gas ahead of the scrubbers and the debenzolized wash oil were designed with a large factor of safety, but, strange as it may seem, the climatic conditions appear to have been ignored, or at least the cooling system was designed for use with a cooling water which did not exist. Indeed, if cooling water with a maximum temperature of



Coking Time 16 hrs. and 30 min. (net).
Pushing schedule very regular at all times.

Absorbent Oil circulated – 72,000 gals. per 24 hrs.

Temperature of gas entering Scrubbers and of W.O. leaving Coolers
varied with that of Cooling Water, within a few degrees.

Recovery of Byproducts from Bitumenous Coal. E.C.P.

20° C. were available, the system would be amply able to recover all light oil from the gas with a high degree of efficiency. On the contrary, the cooling water during July, August and September, 1917, reached an average daily temperature of more than 30° C., whereas, for efficient recovery of light oil from the gas, both the washed oil and gas must be kept below 20° C.

Those benzol plants located near the Great Lakes, or where ample supplies of cool underground water are available, are most fortunate indeed. It has been the history of most inland benzol plants that either improperly designed cooling equipment was installed or the supply of proper cooling water was deficient, or in some plants both conditions existed.

In order to emphasize the vital need of proper cooling water, an hourly and daily record was kept during the months of operation in 1917 of the temperature of the cooling water, of the gas at the inlet to the scrubbers, and of the wash oil as it left the wash oil coolers. In the following table is shown the monthly averages of the cooling water temperature, the volatile matter in the coal as charged into the ovens, and the recovery of light oil in gallons per net ton of dry coal:

Month	Year	Cooling Water Temp., Degrees Fahr.	Per Cent Volatile Matter in Coal Charge	Gals. L. O. per ton of Dry Coal
April	1917	19.30	23.69	1.86
May	1917	21.17	25.29	2.35
June	1917	27.32	24.88	2.11
July	1917	29.88	25.07	1.92
August	1917	29.52	25.23	1.99
September	1917	28.00	25.27	2.21
October	1917	21.10	25.07	2.19
November	1917	16.94	25.23	2.49
December	1917	12.34	25.54 24.78	2.40 2.36
January	1918	8.07	24.87	2.45
February	1918	14.00	24.74	2.27

The variation in the percentage of volatile matter in the oven coal charge is due to small amounts of high volatile coal which was used during certain months. In the middle of December, all high volatile coal was discontinued and Virginia coal alone was charged. Consequently, two sets of values are represented for that month. This table of values is shown graphically also.

A glance at the table or graph shows very clearly the monthly falling off in the light oil recovery as the temperature of the cooling water increases. It is significant also that during the latter half of December (1917) and January (1918), after all high volatile coal had been discontinued, the yield of light oil shows a decided increase. Had this high volatile coal been continued, this increase in yield would have been still more marked.

The table shows an average yield of light oil from the gas during eleven months of the operation to be 2.22 gallons per net ton of dry coal. At the same time an average of 2.49 was shown for November, 1917. Assuming that this high average may have been due partly to the higher percentage of volatile matter in oven coal charge, we will use the average of 2.45 in January, when the coal charge consisted entirely of Virginia coal.

2.45 — 2.22 = 0.23 = gain in light oil per ton of dry coal, due to efficient cooling water.

For an annual charge of 250,000 tons of dry coal, 250,000 × 0.23 = 57,500 = gallons of light oil lost during the year on account of insufficient cooling water. According to our yields of pure products from light oil,

50% of light oil charged = C. P. Benzol.
13% of light oil charged = C. P. Toluol.
50% of 57,500 gal. = 28,750 gals., C. P. Benzol.
13% of 57,500 gal. = 7,475 gals., C. P. Toluol.

Assuming for the above two C. P. products values of 35 cents and $1.50 per gallon, both of which are less than the actual prices paid on the market for C. P. Benzol and C. P. Toluol, the saving in money would have been:

28750 × 0.35 = $10,062.50 on Benzol, and

7475 × 1.50 = $11,212.50 on Toluol, making a total annual saving of $21,275.00.

The above estimate on the saving or gain due to proper cooling water does not include any labor needed for the handling of the extra gallonage, because the present labor force would not have to be increased. However, in order to be strictly accurate, an allowance should be made for additional "still-hours" necessary for refining the above 57,500 gallons of crude light oil. If this extra steam consumption should amount to $3,275.00, and it would be decidedly less than that, the net gain would then be $18,000.00 per year, or 6 per cent interest on an investment of $300,000.00. Or, instead of employing present selling prices of Benzol and Toluol, figure the Benzol at motor fuel value, 25 cents per gallon, and the Toluol at $1.00 per gallon—possible post-war prices—and the net gain would still be approximately $12,000.00 per annum.

In order to be fair to the Gulf States Steel Company, I should state that every effort is being made now to secure desirable water, even to the possibility of installing artificial refrigeration, since deep wells so far have developed no adequate supply of water. Furthermore, on account of the prevalent high relative humidity of the atmosphere, spray cooling, either in reservoirs or towers, does not promise much relief. This is only one of many illustrations of plants where a vital, underlying principle of operation has been neglected, and consequently high efficient operation is impossible.

The writer visited several of the larger coke plants in the North before coming South, and among those places visited found one where thousands of dollars had been expended in making the building and surroundings beautiful and pleasing to the eye, but at the same time overlooked this same proposition of an adequate supply of proper cooling water. The results there were deplorable indeed. The poorest month at the Gulf States Plant showed 1.86 gallons of light oil per ton of dry coal, with coal averaging 26.69 per cent volatile matter, whereas at the above mentioned plant the yield of light oil during at least two summer months averaged less than 1.00 gallon per ton of dry coal charged, and the volatile matter in that coal averaged 30.00 per cent. or more.

In many cases, and this, doubtless, is true to a large extent of the above plant, the yield of light oil is seriously affected by temperature and other operating conditions at the ovens. Perhaps the most vital source of loss at the ovens is the temperature of the upper portion of the oven chamber. It is claimed by those who have made a careful study of these conditions that excessive temperatures at this point will break down Toluol into lower homologues, that is, into Benzol. It has not been the writer's opportunity to make any exhaustive study in a quantitative way of such conditions, but, upon being asked to base a probable yield of Benzol products upon the analysis of the coal to be used, and operating conditions in general, it did not seem probable that more than 10 per cent of the total light oil could be converted into C. P. Toluol. However, since the first day of operation of this plant, it has been our constant effort to control the oven "heats" so that the top of the oven—say about 24 inches down from the top—should be slightly darker than the lower portion. The light oil for eleven months has averaged apprорrximately 13 per cent C. P. Toluol. I believe that this increased yield of Toluol is largely, if not entirely, due to the comparatively cool oven tops.

Another precaution mentioned before is that of keeping the oven walls, doors, joints, charging lids, etc., sealed tightly, absolutely leak proof. Upon this depends in a great measure the quality of the coke, gas and all by-products, yet, in the plant referred to above, perhaps half of all doors, lids, valves, etc., were leaking gas at every possible opening, and the oven tops were so hot that the guide would not permit the visitor to walk across the top of the ovens, lest he ruin his shoe leather. An evidence of further leakage inside of the ovens was a large quantity of dense black smoke issuing from the battery stack.

Only a few of the outstanding needs of careful control and constant analysis of all conditions affecting coke plant operation have been touched upon. There are innumerable places in each of the three main departments, Ovens, By-Product, and Benzol, where the need for close observation and study is very vital. Many of these conditions have never been fully investigated and indeed are not well understood by anyone. Hence, the field for competent and reliable research is a large one.

RADIO TELEPHONY AND THE TREND OF DEVELOPMENT

By F. F. HAMILTON, '14

It must be remembered that radio telephony is decidedly in a stage of experimentation, but great advances have been made in the past few years. Inventors the world over have been trying to develop the art to a commercial standpoint. Laboratory wireless telephones have been common for many years, and today most any physics laboratory can rig up a workable outfit.

This article will take up some of the general underlying principles, so presented as to give an idea of what lines have proven most promisory of commercial development.

The modern Bell telephone as we know it is a highly specialized commercial device that can be depended upon with a remarkable degree of certainty. The simple telephone for example, uses a microphone which transmits the speech from vibrations of the air upon its diaphragm and causes similar vibrations in a metallic electric circuit composed of a battery and a suitable receiver. At some point in the circuit or at the other end of the line is another receiver which transmits the electric waves back into the air as voice waves again. The Bell telephone, however, is not a voice transmitter of the highest order due to different pitched waves travelling over metallic conductors at different speeds. This is very noticeable with some voices.

Let us take from this simple telephone circuit the metallic conductors which connect one station with the other and replace them with the ether of the atmosphere. One now has before him the problem that is known as radiotelephony. The next problem that arises is that of the power required to transmit the waves. We have replaced metal with a very high resistant medium in which we must use electro-magnetic waves. This requires more power.

To manipulate this power by the use of a common telephone transmitter is in itself a difficult problem. Inventors have used all sorts of microphones, but the simple, rugged carbon microphone has proven its worth. This microphone can handle about one-half ampere at the most and keep its sensitiveness for a limited period. The next problem that arose was, therefore, a relaying device that would relay a large amount of power when operated by the microphone. This is easy to do in wireless telegraphy where the only function of a relay is to close a circuit, but in telephony the relay must follow along the curve of speech transmitted by the microphone. Here then was an obstacle. One solution of this relaying device lay in the use of a direct current resonant arc burning in an atmosphere void of oxygen. Various kinds of arcs were used with success. The arcs were high voltage affairs with small currents and were connected in multiple for a larger power.

The arc was used to modulate the field of a generator which produced the large power required. This arrangement was as follows: the microphone produced the vibrations from the air and placed them within the electric circuit. The vibrations were then used to modulate the current of the resonant arc, which in its turn modulated the field current of the generator.

In order to get a good idea of the requirements of such a generator let us look into the wireless telegraph field. Each station has its sending apparatus working on a sharply tuned wave of single frequency and of a pure form. The antenna circuit sends out a pure wave at a definite wave length, which antenna circuit is closely tuned to the sending or closed oscillation circuit. In telephony it would seem that we must send out many wave lengths in order to transmit speech. This is true only in part. Such an apparatus would be both clumsy and inefficient because resonance must be had at each different wave length. If an antenna circuit is not tuned sharply to the closed oscillation circuit the whole becomes inefficient.

Therefore, inventors looked to the high frequency generator of from 20,000-1,000,000 cycles per second. This is a generator which has its field current modulated by the arc. It generates a high frequency current which is induced into the antenna circuit at such wave length as to correspond to the natural frequency of the antenna. The sending outfit although complex in its form sends out a pure, sharp wave of say 50,000 cycles per second.

The development of a generator which will produce a frequency of 50,000 cycles per second has been a source of much study by many inventors and engineers without the result of producing a really commercially efficient machine that can be sold at a moderate price. However, the manufacture of a generator of 10,000 cycles a second is a commercial possibility, and in practice the frequency has been stepped up by means of static transformers. This arrangement is only applicable to large amount of power.

But why take such a frequency when it is so hard to produce? The human ear is the reason; it is sensitive to frequencies between 40 and 20,000 cycles per second. If the ear was not sensitive to frequencies above 5,000 the problem would be much simpler. Then the sending machine must produce a fundamental frequency above that which can be heard or there will be a difficulty at the receiving end.

Let us take an example of a sending machine composed of the proper circuits of inductances and capacities to give resonance; a microphone, an arc, and a high frequency generator outfit. The apparatus is running and distributing the ether with a pure, sharp wave of 50,000 cycles per second. Now, if one speaks into the microphone, the diaphragm will be disturbed, which affects the electric balance all the way through the apparatus and the generator wave is modulated in amplitude to correspond to the nodes and anodes of the spoken wave form. The voice wave is then made to ride upon or modulate the amplitude of the sending wave of the high frequency generator. This allows the circuit to be tuned on one wave length and at the same time to send out what is heard at the other end or receiving station as voice waves. The voice waves are almost always pure and distinct because all frequencies travel at the same speed in the ether. It can readily be seen that the higher the pitch of the sending wave or fundamental the more nodes and anodes there are to any one cycle of voice wave. There are other considerations of wave-length that make themselves prominent which results in keeping the fundamental as low as possible.

This apparatus is not perfect but is the best that has been developed as far as principle is concerned. Just lately an electron relay of the vacuum type, known as a Fleming valve, has been developed which will within itself modulate about two kilowatts of energy which in turn has been modulated by the microphone. This valve is a great step toward perfecting the sending apparatus, for arcs are troublesome at best and cannot always be relied upon the instant that one needs them. These valves are easy to operate and are almost fool-proof, but they are more delicate than the arc and produce better modulation. The commercial name of this valve is Pliotron.

For small distances the Pliotron can be connected inductively to the antenna circuit and made to produce telephonic communication of the first order. In this form the sending station sends out waves without the use of a high frequency generator, for the Pliotron takes care of that within itself. For large powers these Plitorons can be used instead of the high frequency alternator and will in all probability antiquate it very soon. The arrangement is as follows: a microphone modulates a single Pliotron which in turn modulates a bank of Pliotrons inductively connected to the antenna circuit. We may soon see the development of a yet larger therminic valve artificially cooled which will handle 5-10 kw. Such a size would be sufficient for all ship stations, for it is aboard ship that the wireless telephone will be used to great advantage. The commercial message is generally secret and in code so why substitute a wireless telephone for a wireless telegraph? At sea the more stations that understand the message the more the co-operation that can be had.

The receiving of wireless telephonic messages has been solved very satisfactorily. The instrument consists of an antenna circuit inductively coupled to a closed resonant circuit in which is located a detector and a pair of phones. There are several detectors that have proven successful, Fessenden's electrolytic, and lately the audion, audiotron, and the kenetron.

All the above apparatus is somewhat complicated as a whole but today is taking a commercial form, which necessitates ruggedness and dependability. By some of the above methods articulate speech has been transmitted several thousands of miles.

Although there are many developments now that are kept secret, the wireless telephone is waiting for the present crisis to pass over, after which one will see many small stations spring up as did wireless stations a few years ago. These stations owned by scientists, near scientists and larksters will be a great help in stimulating the development of scientific minds among our youth. Let us hope that we may soon have the freedom of the ether that we did a few months ago.

NOTES ON INDUSTRIAL EXPLOSIVES

By D. M. JACKMAN, '11

Despite the fact that explosives are widely and generally used there are so few persons who have a real knowledge of their nature, manufacture, properties and uses, and indeed so many entirely erroneous impressions are commonly held in regard to them, that the writer believes he can do no better in attempting a contribution to the Purdue Engineering Review than to write a simple article in rather a non-technical style on the subject of explosives, with special regard to those used in engineering.

This lack of understanding of explosive materials is due to a number of causes, chief among which is the fact that most reference books treating the subject are old and out of date, and the very general, but largely unfounded, feeling that explosives are essentially dangerous and should be avoided whenever possible.

This is a subject which should be of interest to engineers and engineering students, for there arise many instances where costs might be reduced by using explosives rather than to attack the problem by other methods, and again in many cases where there is no question as to the necessity of using explosives, the choice of the explosive used will have an important bearing upon the success of the undertaking. In this article, both because of the breadth of the subject as compared with the space permitted, and also because of the fact that many features of the explosives industry are regarded as trade secrets, no attempt will be made to discuss the manufacture of explosives, but only to give an impression of their types, properties and uses.

It is hardly necessary to define what is meant by the term explosive, but we may say that any substance or mixture is an explosive if it is capable of being made to undergo a sudden chemical change with the liberation of energy and development of high gas pressures. It will be noted that we have spoken of a sudden chemical change. Probably most persons without stopping to consider, would say that all explosions are instantaneous, and that one explosive acts as quickly as another. It will be explained later, however, that there is a great difference not only in the manner, but also in the speed with which different explosives act, and that this is a very important factor to be considered in selecting an explosive for a given duty.

Chemically, explosives may be divided into three classes, as follows:

1. Mixtures of two or more substances which are capable of being made to react to produce the explosion. One of these substances is essentially an oxidizing, and the other a reducing agent. The best example of this type is the old-fashioned black powder, consisting of potassium nitrate, sulphur and charcoal.
2. Chemical compounds which can undergo a breaking up of the molecule and rearrangement of the atoms into other molecules, with evolution of heat. Examples of this type are nitro-glycerin, nitrocellulose, and T. N. T.
3. Chemical compounds which decompose into their elements with explosive violence. Examples of this type are mercuric fulminate and the so-called lead azide.

All three o fthe above classes have members which are commercially important.

DEFLAGRATING AND DETONATING EXPLOSIVES

If we classify explosives according to their manner of exploding we have only two classes, with no very sharp line drawn between them. These are the explosives such as black powder and smokeless powder, which merely burn, the reaction taking place only on the surface; and those such as dynamite, nitroglycerin and T. N. T., in which the reaction occurs almost instantaneously throughout the entire mass. Explosives of the latter type are said to detonate. The phenomenon of detonation is one which is not well understood, and, as has been said, no sharp line can be drawn between detonation and mere burning, because under certain conditions the rate of burning of some explosives can rise to such a point that it practically amounts to a detonation. Some explosives, in fact many of them, can be made either to burn or detonate, depending on conditions. So, while it will be seen that the difference between burning and detonation is a difference of degree, rather than of kind, and while no sharp line can be drawn, the distinction is easily justified by the fact that some explosives always explode by detonation, while others cannot be made to detonate, and by the additional fact that the effects produced by burning and detonating explosives are radically different. It must not be understood that detonation is an instantaneous phenomenon, nor that it takes place throughout the mass of an explosive at absolutely the same time. A detonation starts from a given point and travels away from that point in all directions throughout the mass of the explosive, with a velocity which is measurable, and which depends upon the nature and density of the explosive. The velocity with which the wave of detonation travels in commercial dynamite varies from 5,000 to 20,000 feet per second, depending on the nature of the powder, and the use for which it is intended. The different effects produced by different explosives are largely dependent on their rates of detonation.

SENSITIVENESS OF EXPLOSIVES

Another property of explosives which is of great technical importance is their sensitiveness. The importance of this property manifests itself in two ways, only one of which is, perhaps, sufficiently obvious to be apparent at first thought. It is very evident that, if an explosive is too sensitive to shock, friction or heat, it will be dangerous, but that is only one side of the question. There are a number of substances which are good and powerful explosives, which are so insensitive that they can be made to explode only with the utmost difficulty or by very special means. Ammonium nitrate is perhaps the best example of this sort. It is, when properly used and in normal times, one of our best, most powerful, and cheapest explosives, but it is so insensitive that many persons would probably not think of it as an explosive. One may strike it on an anvil with a hammer, and merely crush it; heat it in a fire and it simply and quietly decomposes into nitrous oxide and water vapor; yet by the proper means it can be detonated with almost as great violence as nitroglycerin. On account of the extreme difficulty with which it is detonated in the pure state, it is generally used in dynamite, admixed with other ingredients and enough nitroglycerin to make the mixture easily detonated.

The sensitiveness of an explosive is independent of its other properties, and stands in no definite relation to the strength. An example has just been given of a very powerful explosive which is so insensitive that it would hardly be regarded as being an explosive by most persons, and on the other hand we have mercury fulminate and the so-called nitrogen iodide, which are extremely sensitive, but comparatively weak explosives. The latter substance is of no practical importance, but serves well as an illustration of a very sensitive explosive, being so very sensitive to friction and shock that when touched with a feather, or even when a gentle current of air is blown upon it, it detonates sharply.

A few words might profitably be said about the sensitiveness of commercial explosives, and what is necessary to cause their detonation. Black powder burns quickly if ignited in the open, but explodes if confined. Smokeless powder behaves in the same manner, but in general burns more slowly, depending on its physical form. Dynamite when ignited almost always burns quietly, and even more slowly than smokeless powder, but occasionally explodes. The sensitiveness of dynamite to shock is much less than is commonly supposed. The writer well remembers the care and delicacy with which he first dandled dynamite, fearing that if, for example, a cartridge should fall from his hand and strike the floor, an explosion would result. As a matter of fact, a cartridge might fall from the top of a twenty-story building and strike the pavement below without great danger of an explosion. There would be a possibility of its exploding, although it would be small.

If Nobel had not discovered that mercuric fulminate will cause the detonation of nitroglycerin, the development of the explosives industry would have been delayed for many years, and if no substance having a similar action had ever been discovered, there never could have been an explosives industry as it is now known. This is because dynamite can be detonated in a manner which is satisfactory to the quarryman, the minter, the farmer, and the engineer only by the detonation of some other substance such as mercuric fulminate, or the so-called lead azide. A fuse will not properly explode dynamite, but it will cause the explosion of a small quantity of mercuric fulminate, which in turn will explode the dynamite. Hence, we have the so-called blasting cap, or the electric detonator. A blasting cap consists of a small capsule of copper, into which is packed a charge (usually about one gram) of mercuric fulminate, or a mixture of four parts of mercuric fulminate to one of potassium chlorate. The electric detonator is exactly the same as the blasting cap, save that instead of being used with a fuse, it is exploded by an electric current. Owing to the costliness of mercuric fulminate, other substances such as lead azide, (PbN_6), which is a salt of hydronitric acid, (NH_3), T. N. T., tetra-nitro-aniline, and other explosives which have been tried as substitutes for mercuric fulminate in the manufacture of detonators, with more or less success, but apparently they have so far failed to prove themselves equal to it.

The action of these substances in bringing about the detonation of other explosives is an interesting one, and is not well understood. Mention has been made of the fact that mercuric fulminate has been found most satisfactory for practical use, but that other substances had been tried with varying degrees of success. Of many substances which have been tried, only a few have the ability to detonate other explosives. The reason for this is not known. Nitromanite, diazo-benzene-nitrate, sulphur-nitride, (N_4S_4), silver hydronitride, trimercuraldehyde-perchlorate, and basic mercury nitro-methane are all powerful explosives, the first three being much more powerful than the others, but of all these only the fourth and fifth have any marked ability to cause other explosives to detonate. We cannot even say that there is any one of the explosives which do detonate other substances, which is more effective than any other, for while one of the initial detonators which we shall call A may be more effective than B in detonating a secondary explosive C, on the other hand B may be more effective than A in detonating another secondary explosive D. For instance, mercuric fulminate is a better detonator for nitroglycerine than is silver hydronitride, but at the same time .25 gram of mercury fulminate is required to detonate picric acid, while .02 gram of silver hydronitride will suffice. No satisfactory explanation of this phenomenon has ever been offered.

DYNAMITE

Another incorrect impression prevails as to the materials of which dynamite is made. There is a very general belief fostered by the older text and reference books that dynamite consists essentially of nitroglycerine absorbed in infusorial earth or kieselguhr. As a matter of fact, kisselguhr is never used in this country at the present time as an absorbent, but almost any other porous or absorbent material may be. The absorbents used at the present time are all of the so-called active type; that is, instead of using an inert substance such as kieselguhr to absorb the nitroglycerin, a mixture of wood pulp, corn meal, sulphur, ground coal or other combustible substance, and some oxidizing substance such as sodium nitrate, ammonium nitrate, or potassium nitrate, is used as the absorbent. The advantages of this procedure are obvious. If we use an inert absorbent, we must depend for our explosive power entirely upon the nitroglycerine, and furthermore, the kieselguhr does not merely do nothing itself, but it does worse than nothing by cooling down the gases produces by the explosion of the nitroglycerin, and keeping them from doing as effective work as if allowed to expand uncooled. The active absorbent itself enters into the reaction and develops a considerable quantity of the total power of the powder. Not only may the absorbent be said to supplement the nitroglycerine, but as the cost of nitroglycerine has risen by leaps

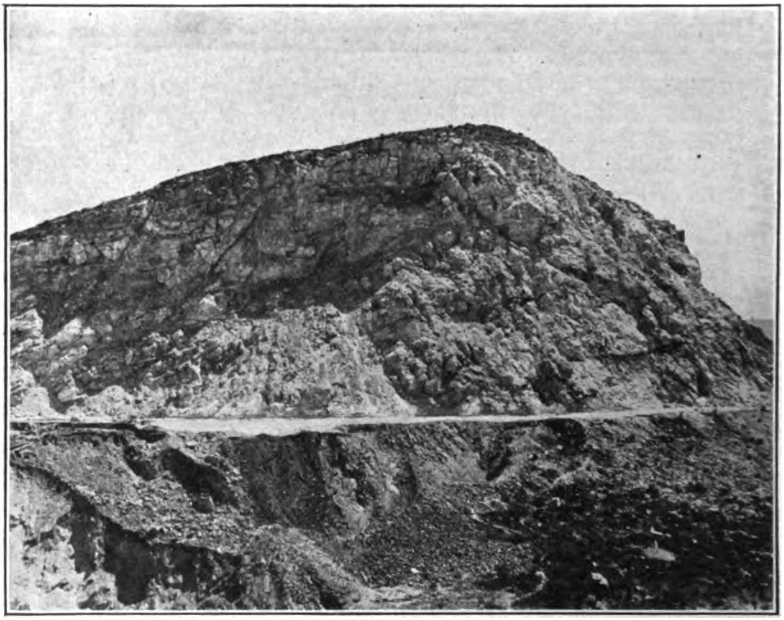


Fig. 1. Ready for a big blast in a limestone quarry of a cement mill in California. A large number of holes have been drilled and loaded and will be fired simultaneously by means of electric detonators and a blasting machine

and bounds within recent years, absorbents have been selected with a view to the explosive value which they possess, until some of our best modern powders derive about 80 per cent of their explosive value from the absorbent, and only enough nitroglycerin is used to "sensitize" the powder. That is, we select ingredients such as ammoniun nitrate or ammonium perchlorate, which are almost or quite as powerful as nitroglycerine, but which unfortunately are too insensitive to be used alone, and add to them enough ground coal, wood pulp or other combustible to react with the oxygen furnished by the ammonium salt, and enough nitroglycerine to enable us to detonate the mixture with mercuric fulminate. By this means, we are able to manufacture powders cheaply which are just as powerful, and for many purposes equal, or even superior to the more expensive powders in which nitroglycerin is the essential explosive ingredient. Some of our best powders contain only 10 per cent of nitroglycerine.

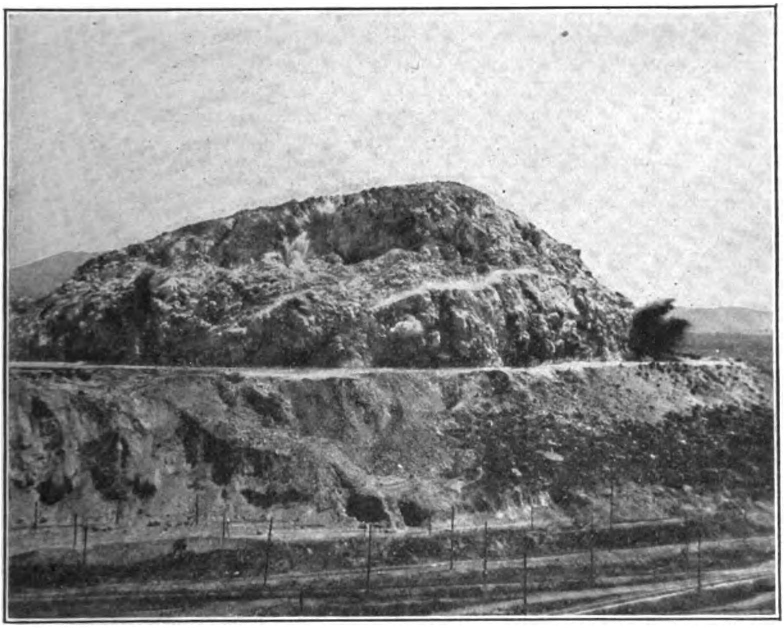


Fig. 2. The same, just as the blast is fired. For the safety of the photographer it was necessary to take this exposure from a greater distance than the other two. Note the gases from the explosion just breaking through on the right. Also note how just to the left of this point the whole mass of the rock has been broken loose and is being thrust forward. About halfway up the face the fracture can be seen running in a roughly horizontal direction.

ESSENTIAL REQUIREMENTS OF A GOOD DYNAMITE

There are certain general requirements which apply to all dynamites, regardless of their intended use, and still other special requirements which are peculiar to the particular use for which the powder is intended.

Among the general requirements, the powder must be chemically stable, and not subject to decomposition or other change on storage, it must be as resistant toward water as possible, must be sensitive enough to be easily detonated by a number six detonator, but still not too sensitive to be safely handled; it should be as dense as possible; it must be non-freezing, or at least freeze at as low a temperature as possible, and must be as cheap as may be.

As for the special requirements, they depend upon the purpose for which the powder is to be used. If it is to be used in a gassy or dusty coal mine, it absolutely must be a "low flame" explosive, and it should have a low velocity of detonation. By a "low flame" powder, we mean one

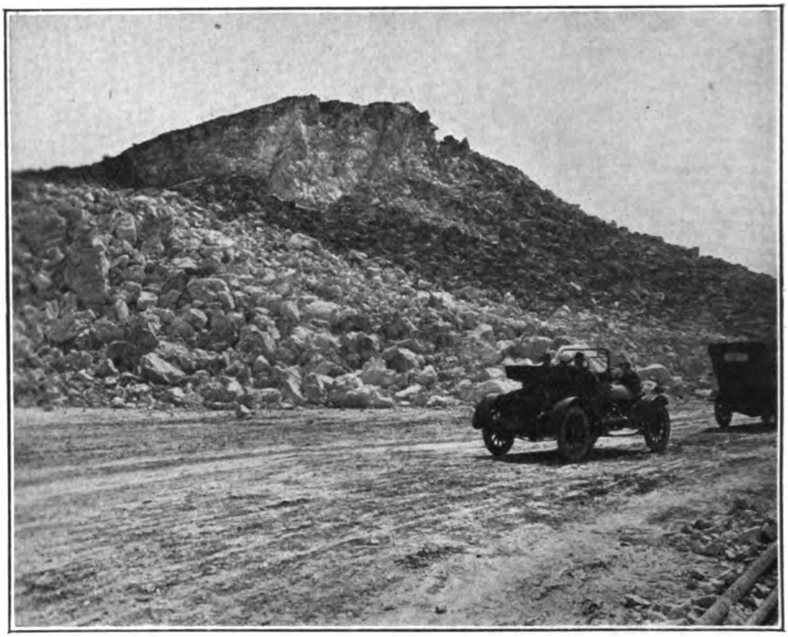


Fig. 3. After the blast. The whole side of the cliff has been shot down in such form that it can be loaded into cars and hauled to the mill to be fed into the crusher.

of the "permissible" type, so designed that the temperature of the flame developed on exploding it is low enough that it will not ignite explosive mixtures of air with dust or mine gas. A powder may be made "permissible" in a number of ways.

If a powder is to be used in a mine where there is no gas, but where the ventilation is poor, it must have a positive "oxygen balance," that is, must contain an excess of oxygen over that required for its own combustibles, so that there will be no danger of the formation of carbon monoxide or other noxious gases when the powder explodes, since these would be injurious to the health of the workmen.

If a powder is to be used for blasting hard, flinty rock, where the expense of drilling is great, a dense, powerful powder must be selected which will give a maximum amount of disruptive force for a minimum of drilling. In this case the powder should have a high rate of detonation, especially if it is desired to "bring down" the rock in small pieces.

If earth or soft rock is to be blasted, or if stumps are to be blown out, a powerful "fast" powder such as would have been used in the preceding case would not be effective. Instead, we should use a low-grade, "slow" powder, i. e., one having a low rate of detonation, which will give us a rending and thrusting, rather than a shattering effect. In this case the expense of drilling the holes would be slight, and there would be no danger from noxious gases. We should therefore not care whether the powder were dense or not, nor whether it had a good "oxygen balance" or not.

If, again, we are called upon to do submarine blasting, or wherever there is much water, we should probably use a gelatin dynamite, since the gelatins are practically waterproof. We should avoid the ammonium nitrate powders in such work, because, while they are much cheaper than gelatins, they are not very resistant to water, and there would be danger that they would fail to develop their proper force, if they did not miss fire entirely.

In quarry work, one can bring down his rock in large or small blocks at will by selecting a "slow" or a "fast" powder.

From the above remarks it will be seen that there are very many kinds of work to be done with explosives, and that each kind has its own special requirements which the powder manufacturer must meet, in addition to the general requirements for all powders. Some of these special requirements may be so urgent that they must be met even though other desirable qualities must be sacrificed. It is an easy matter to meet any one requirement, and a comparatively easy matter to meet any two, but of course, the more requirements there are to be met simultaneously, the more difficult the task. Nevertheless, powder manufacturers are able to make a powder to comply with almost any set of requirements.

TYPES OF POWDERS

To meet the many needs which have been mentioned above, many different types of powders have been developed.

The chlorate powders, consisting of potassium chlorate, some nitro-aromatic compound and a carbonaceous absorbent, have never been important on account of their cost and their dangerous character.

The nitro starch powders, consisting essentially of nitro starch, sodium nitrate and possibly ammonium nitrate, are cheap, non-freezing and have a high rate of detonation. They are bulky and insensitive, however, and not very re-

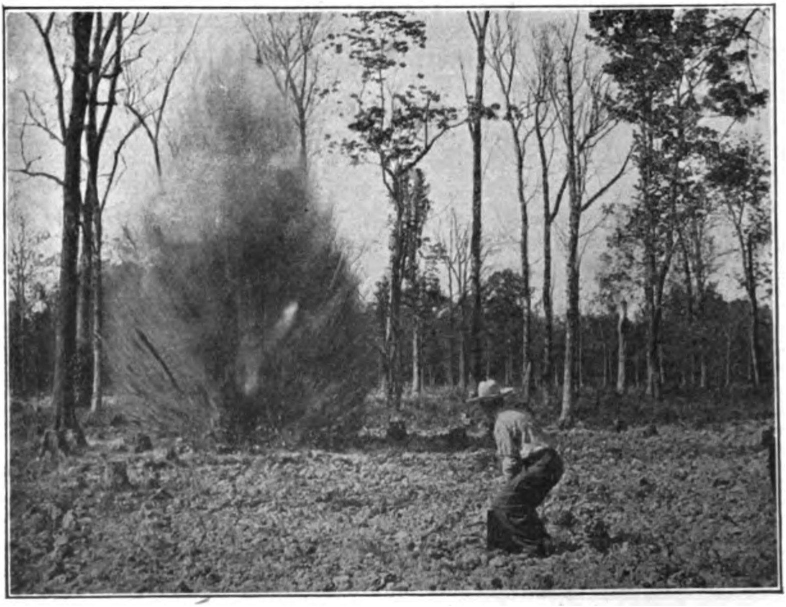


Fig. 4. Removing a stump with dynamite. Also showing the use of the blasting machine

sistant to water. Until within recent years, during which time the cost of nitroglycerine has increased greatly, they never were serious competitors of nitroglycerine powders.

By far the most important class of powders is the nitroglycerine type. This class has several subdivisions, as, for instance, the "straight" powders, permissibles, ammonium nitrate powders, and gelatins. Any of these may be made "low freezing" by various means. The straight powders are the simplest representatives of this type. They consist of nitroglycerine absorbed in a carbonaceous absorbent, usually wood pulp, and sodium nitrate. They are powerful, and cover a wide range of uses. The permissibles may be of the ammonium nitrate class, the carbonite class or the hydrated class, depending on the means employed to reduce the flame temperature. They are intended for use in gassy or dusty mines, and with the exception of the ammonium nitrate group, are not to be recommended for other uses. The ammonium nitrate powders have ammonium nitrate used to a greater or less extent as a substitute for nitroglycerine, and depend in part on it for their strength. They are cheaper than the "straight" powders of equal strength, and are very much used for general work. The

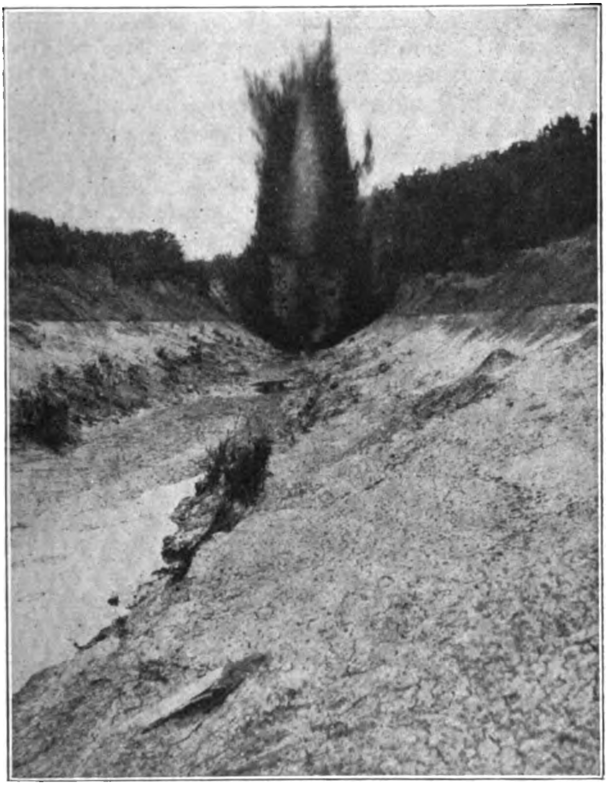


Fig. 5. Blasting a ditch. A section of finished ditch is shown in the foreground while another portion is being blasted in the background

gelatins are so-called because of their gelatinous consistency, which is produced by the addition of a small amount of nitrocellulose. They are recommended for "wet work" and for use in hard rock, because of their great density and water-resisting powers. Any of the nitroglycerine powders may be made low freezing by the use of specially treated nitroglycerine, or by the addition of certain substances which lower the freezing point of nitroglycerine.

THE USES OF EXPLOSIVES

It is not necessary to dwell long on the uses of explosives. Everyone knows that they are necessities in mining, tunneling and quarrying, and that they may be advantageously used in many other ways, among which may be mentioned removing obstructions, setting young fruit trees, and blasting dicthes. Not only can holes for setting fruit trees be blasted more cheaply than they can be dug, but on account of the loosening up of the subsoil by the blast, trees which are set in blasted holes grow more rapidly, and come to bearing sooner than trees set in dug holes wherever the subsoil is inclined to be hard.

If a ditch is to be blasted, all that is necessary to do is to drive a bar down to the depth required for the ditch, and load the hole with powder, making a line of holes so charged, about eighteen inches apart, along the course which the ditch is to take; the nexplode the charges simultaneously and there is the ditch.

THE PROPER USE OF EXPLOSIVES

The proper use of explosives begins with the selection of the proper explosive for the work which is to be done. Having made this selection, the next matter is proper loading, but that cannot be discussed here further than to say that the drilling and loading of holes should be entrusted only to experienced men, not only from the standpoint of safety, but of economy of powder as well. Next see that the powder is well thawed out if the weather is cold, before it is used. Frozen powder cannot be expected to do good work. Do not thaw powder by putting it into a pale of hot water, by putting it on the stove nor in the oven. Where a large amount of powder is constantly being used, as for instance at a large quarry, a thaw house should be provided, but where this is not feasible, the powder should be kept for some time before it is to be used, in a moderately warm place, or in a thawing kettle such as are supplied by the powder manufacturers. Last, but not least, use good detonators. Use nothing less than a No. 6 detonator and use a No. 8 if the powder is inclined to be insensitive. In many cases proper results can be obtained only by firing a large number of holes simultaneously. This is best done by means of electric detonators and a blasting machine.

THE STORAGE OF EXPLOSIVES

Explosives should be stored in a cool, dry place at a safe distance from other buildings. In storing and transporting explosives, dynamite should always be kept separate from caps, detonators and the like.

If proper care is taken, the manufacture, transportation, storage, and use of explosives need not be attended by any great amount of danger. The impression which prevails as to the danger in handling and using powders results from accidents which are due to carelessness or ignorance of the proper method of handling them. An attempt has been made in this paper to correct some common misconceptions in regard to explosives, but lack of space has made it necessary to touch only the most important points. It is recommended that anyone who is called upon to use much powder should make himself thoroughly familiar with the subject. The United States Bureau of Mines is furnishing much valuable information to the users of explosives, and some of the later and better reference books dealing with the subject give considerable information.

GRAPHICAL METHOD IN PLANT OPERATION

By W. B. VAN ARSDEL, '13

The present widespread tendency toward more thorough-going use of scientific methods in industry and business has been accompanied by a remarkable growth of interest in the graphical presentation of data. Any one who has followed the literature of the engineering professions, particularly during the past five years, must have noticed the increasing importance attached to diagrammatic short-cuts, the rapid development of hitherto neglected methods, and the appearance of many new types of recording instruments.

SCIENCE IN THE PLANT

The scientific control of an enterprise necessarily involves the careful collection and criticism of quantitative data concerning it. It is easy to find in almost any factory, however, processes which are fondly held to be above science—"arts," which are best left to the discerning judgment of a skilled workman. The attempt to introduce any mode of operation which threatens to reduce the mystery of such operations is certain to meet at the start with the unqualified hostility of the artisans who feel themselves responsible for it. In his attempt to prove his case, an otherwise conscientious man will sometimes deliberately falsify data or allow preventable accidents to happen; but the more common and insidious opposition arises unconsciously from the conviction in the workman's mind that the familiar, time-tried process cannot possibly be improved. Indications to the contrary are hastily forgotten, while every crumb of comfort is eagerly discussed and given unusual significance. Data taken by a man in this state of mind are often worse than useless.

If the records of plant operations are to stand searching criticism, the methods of measurement must be above reproach. Investigation of a process for the first time, therefore, will usually call either for the development of new types of measuring instruments or for the careful adaptation of old instruments to the new problem. The fact that a process has for a long time resisted reduction to a "science" is usually sufficient proof that the real difficulty lies in securing suitable means of measurement. In such a case the development of a single appliance may provide the key to the entire situation.

The vital point of a plant's record-system is, however, not so much the collection of the data as its analysis and "working up." The mere possession of a tall pile of charts from the recording instruments in the boiler house does not reduce the coal bill; only a patient, thorough-going study of the figures, grounded in accurate knowledge of the plant equipment and conditions, can result in the formulation of definite conclusions and the building up of consistently high efficiencies.

THE REASON FOR GRAPHICS

Such study, without the aid of graphical representation of some kind, would present most discouraging difficulties. While it is true that there is no important operation ordinarily performed graphically which cannot be performed equally well by strictly analytical methods, the difference in labor and time consumed is in most cases quite astonishing. The most important disadvantage of the row of figures, however, is its poverty of suggestion. Numbers all appear so much alike that the mind finds it difficult to grasp the variations recorded—the presence of maxima or minima goes unnoticed, or the long, gradual change is masked by the seemingly random variation of the figures. As has been noted above, it is just such suggestions which are most needed in the study of plant data; when even the slightest indication of the figures must be critically examined, the broad hints offered by the graph cannot be ignored.

With a certain type of "practical" mind which is now quite common, belief in the possibilities of recording instruments and other graphical records has become so exaggerated as to be a real superstition. Having experienced some striking examples of their usefulness on occasion, these worshippers of scientific magic invest extravagantly in instruments to be installed in every possible position. Charts then accumulate for weeks or months on pegs in the office, whence they are periodically "cleaned up" by the janitor, and no one has been the wiser for the information they held. This type of mind, moreover, usually overrates the "intelligence" of the instruments, does not realize that they are at best only a compromise between conflicting requirements, and are—must be, in fact—adjustable at will to give almost any reading. Absurd results are almost sure to follow.

On the other hand, the works manager who approaches his problem in the true scientific spirit, demanding accurate, thorough-going, quantitative knowledge of every operation, is certain to be fully justified in his confidence. It is indeed a rare process which can be performed as economically and as certainly by "rule of thumb" and "judgment" as by quantitative—and especially graphic—control.

GRAPHIC CONTROL RECORDS

Several types of problems may be recognized as requiring different kinds of graphic control They fall into two classes—one calling for recording instruments, the other requiring point-by-point plotting of observed data.

Perhaps the most obvious situation which justifies the use of a recording instrument is encountered when a variable should be followed night and day, week days and holidays, while attendance is only possible during, say, eight hours on week days. A simple case is the recording of atmospheric temperature, sometimes an important factor in plant operation. A similar situation arises when the variable changes so rapidly that occasional reading are likely to miss the most important values—for instance, peak loads in a power house. The recorder is "always on the job." Again, the recording instrument can usually be trusted to act as the impartial umpire, acceptable to both parties, in the event of one of those small disputes which occasionally arise between different departments of the mill; if steam-heated dry-kilns cool off during the night, while the boiler house firemen maintain stoutly that the needle never left the 100-pound mark on their gauges, one or two recorders, wisely placed, will fix the source of trouble. Finally, instrumental records are practically the only means of obtaining reliable data from a process which is manually controlled and which affords the workman an opportunity to cover up carelessness or unskillful operation by merely juggling his figures.

Other variables, however, require the point-by-point plotting from given figures. This is naturally the case with discontinuous, unconnected quantities, such as the number of employees in a department, or the analysis of a product. Again, it frequently happens that a variable is either relatively unimportant, and its record not worth the outlay on an expensive instrument, or the required readings are to be taken only at long intervals, in which case a continuous record is superfluous. Sometimes the duty of reading instruments is assigned to a workman merely to keep him attentive to business and watchful of the progress of an operation. The recording instrument, moreover, does not permit of frequent and speedy averaging or summation of figures, and in case such results are desirable it is usually found best to take periodical readings from an indicator.

THE USE AND ABUSE OF RECORDING INSTRUMENTS

It is almost self-evident that careless installation of instruments will result in gross errors. For instance, a themometer will not indicate the true temperature in a kettle if its bulb lies close to the side, between two steam-heating colis; and a pressure gauge installed in ignorance of the fundamental laws of hydraulics may indicate far from the correct value.

A type of error which is more difficult to trace and eliminate is the "systematic error" arising from faulty design or construction of the instrument itself. It may be said in general of the many recorders now on the market, that a high degree of scientific skill is evident in the design; some of them carry into industrial practice the most refined methods of the physical laboratory. Others, however, depending on simplified assumptions which are only approximately true, are occasionally subject to serious aberration. The connecting tube of certain types of recording thermometer, for instance, introduces an incalculable variable into the result unless its whole length is kept at some constant temperature; this "stem differential," as it has come to be called, becomes important when the difference between two nearly equal temperatures is in question, as in the recently developed wet- and-dry bulb humidity recorders. Another type of systematic error is illustrated by the time-lag between a change of temperature and its indication, which depends, of course, on the mass of the thermometer bulb and the fluid contained in it.

Many of the minor errors of a recorder may be eliminated by careful calibration. It is not often that an instrument comes from the maker requiring no attention before use; most frequently the zero point is found to be displaced and the rest of the scale equally shifted. Checking at one point against a good standard corrects this error. When the multiplying mechanism is incorrectly adjusted, two fixed points are necessary, at opposite ends of the scale if possible. Finally, for very accurate work, the error at a number of intermediate points will be determined and plotted in the usual style of correction diagram.

It may be reiterated that the permanent value of the record of an instrument lies not so much in the record itself as in the interpretation and conclusions drawn from it. Maxima and minima in the curve are always significant, and will usually repay careful correlation with the operating conditions which produced them. Average values and integrated totals are usually required in any extended investigation, and these are not obtained without some labor. Mechanical integrating devices are sometimes made a part of the instrument, as in some types of steam-flow meters, but since they operate like a planimeter on the revolving chart, the inaccuracy is often great. For averaging graphical records on uniformly graduated charts the Durand-Bristol integrator* has been found to be a time saver. Such summaries and averages as are taken from the individual records should then be correlated on a point-by-point graph, so that long-period changes will be apparent.

POINT-BY-POINT PLOTTING

The second graphical method, namely plotting discontinuously separate values of the variable, has very different characteristics. Perhaps its greatest usefulness lies in the representation of the properties of a product, from batch to batch, or from day to day; the analysis of consecutive lots of coal as purchased; the results of physical and chemical examination of test pigs from a blast furnace; and similar problems where a number of characteristics change simultaneusly. Again, the manager can follow specified test pieces through a long process and from his graphical record of their history make at least a good guess as to the cause of any unusual characteristics. For such a purpose mere columns of figures would prove almost useless, since they lack the very element of suggestion which is needed.

When a variable has been plotted for some time it usually becomes advisable to keep track of average values, and control the process by reference to the direction and amount of deviation from the average. Two methods of following the average are in common use; when it is likely that the optimum conditions are absolutely constant and are most likely to be approximated by the average of a great number of observations, a cumulative average is calculated and plotted from day to day along with the individual data. Secondly, when it is more likely that the curve will present a long, slow variation of relatively great magnitude as well as rapid fluctuations of smaller degree, an "overlapping period-average" should be calculated; this is the average of any desired number of preceding values, sufficient to eliminate the short period irregularity.† An instance of its use is the control of processes in a plant where conditions are being steadily improved, or vice versa, and where variations from a period-average will suggest changes to be made immediately.

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*A full description and explanation appears on p. 87 of "Power-Plant Testing," by J. A. Moyer.

†This average is easily computed from point to point by adding (algebraically) to the average at the first preceding point 1 nth of the difference between the new observation and the nth preceding observation, where n is the number of observations being averaged.

CALCULATION CHARTS

The most prolific recent development of graphics has been in the field of nomography, or graphical calculation. Recent handbooks contain abundant evidence that all branches of engineering are coming to value these convenient short cuts* and it seems probable that their use will be extended to cover many calculations which are commonly regarded as being too tedious for practical purposes. They are of great aid to the engineering designer, and are principally used in the drawing or design room, but there is also abundant field for their use in the plant.

A common problm in practice is the determination of a quantity when one or more others related to it are given in mathematical terms, the solution of an equation The relation is not always simple, and it becomes necessary to either work out a table giving all of the values which will be required, or to express the function graphically. When there are more than two independent variables, the tabulation of numerical solutions becomes almost impossible, while even for one the advantage of the graph is marked. For instance in the very common case of a horizontal, cylindrical tank with bumped ends, the volume of liquid corresponding to a given depth showing in the gauge glass would be simply and accurately represented by a curve on rectangular coordinates, while for the same degree of accuracy a rather long table would have to be constructed. If the problem is to determine the required weight of one component of a mixture, given the weight and percent purity (or specific gravity) of another component which is to form a specified proportion of the whole, tabular methods become very cumbersome; a very simple alinement chart, however, will express the whole relation.

An excellent example is described by Taylor.† As the result of many years of work the quantitative connection between all the factors involved in machining metals was established. Then to run his machine at the best speed, to set his tool at the best angle, to give it the best rate of feed, the machinist would have had to solve equations which would have kept a good mathematician busy longer than the job itself lasted. Tables were out of the question. A slide rule was devised (essentially a graphical method of solution) which reduced the determination to a matter of a few moments.

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*See, for instance, Marks' "Mechanical Engineers' Handbook" for many illustrations—pp. 259, 270, 342, 691, 734, 981, 1360, 1650, 1678, etc. Also "Manual of Chemical Nomography," by H. G. Deming, University Press, Champaign, Ill.

†"Principles of Scientific Management," p. 57.

GRAPHICAL METHODS IN PLANT RESEARCH

It has already been suggested that betterment of plant conditions oftentimes follows from the careful study of plant records. For formal investigation of a process, however, or "research," there are methods of study which are likely to prove more fruitful than mere analysis of existing data. It will sometimes be necessary, for instance, to simplify interpretation by separating the variables. In ordinary operation, many conditions change at the same time, so that uncertainty exists as to which condition was really responsible for an unusual result; if the process can be rigidly controlled so that one variable at a time can be investigated, the controlling ones may be accurately determined; if not, "graphical guessing" will be the best substitute.

An example will illustrate the latter method. Suppose that a food product as produced is not at all uniform in its keeping qualities; it contains percentages A and B of supposedly neutral ingredients; percentages C and D of possibly deleterious ingredients; it has been subjected to a temperature T during manufacture, and was treated by a purifying process to an extent which may be called P. The degree of perfection, K, of a large number of representative samples having been determined and expressed numerically on some scale, the first step would be to plot values of, say, C, on rectangular coordinates. If our guess as to the influence of C were a good one, the points would not be scattered at random, but would show some regularity, permitting a line, straight or curved, to be drawn through a rough average position of the points. Individual variations would probably still be quite large, however. The same procedure would be used to relate K in turn to D, T and P, and even to A and B, in an effort to decide whether any correlation at all existed. To carry the work a step further, the distance of individual points from the K-C curve would be plotted against corresponding values of D. If C and D were really the only two factors affecting K, the new points would form a tolerably smooth curve. The further extension of the method, including approximate determination of the relative importance of all of the factors, follows in an obvious manner. If all of the work, however, fails to reduce the points to some semblance of order, an important variable is evidently being neglected, and more data is needed.

Sometimes the nature of the problem requires that a prediction of some kind be made, proceeding from known data and exterpolating to conditions not yet realized. It is commonly recognized that this process should be used with great caution, but there are cases where exterpolation may be made quite certain, especially when an empirical formula can be determined graphically on the basis of some knowledge of the variable. For instance, in many processes it is known that the graph of the quantity, if carried far enough, will approach a known value asymptotically; then a comparatively small group of points, indicating the general shape of the curve, will permit the extension of a logarithmic or hyperbolic curve to a considerable distance. Good discussions of the methods will be found in recent publications.*

CONCLUSION

The wide-awake engineer can not, and does not, neglect or despise graphical methods in operating the plant, in calculation and design, or in original research. He has at his command increasingly accurate instruments, a great variety of convenient, time-saving methods, and in the literature on the subject, a growing body of illustrative examples. The eminent success which has attended the judicious application of these old principles should inspire their more widespread use. The college courses in mathematics might very well undertake to provide a good foundation by including a brief study of some of the other systems of coordinates besides rectangular and polar—in particular parallel linear (as used in the alignment chart), proportional, trilinear, etc.,† since they have assumed such importance in recent work. It is not too much to say that graphics is to the plant engineer what the calculus is to the mathematician, what the check book is to the business man, what the jack knife is to the school boy—an inseparable companion, an indispensable tool.

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*J. W. Mellor, "Higher Mathematics for Students of Chemistry and Physics," pp. 322-332. T. R. Running, "Empirical Formulas."

†J. B. Peddle, "The Construction of Graphical Charts."

THE FIXATION OF NITROGEN

By G. W. Payne, '17

In any technical process there are three things which govern the price of the final product: first, the cost of the starting materials; second, the expenditure of energy necessary to convert them into the compound required; and third, the overhead and operating expense of the plant.

For the manufacture of nitrogenous compounds, the cheapest source of nitrogen is certainly the atmosphere. We have to obtain, however, not only the nitrogen, but also some comparatively abundant substance with which to combine it, and then devise an economical method of effecting the combination. Since nitrogen and oxygen occur in the atmosphere in what is, for practical purposes, an unlimited quantity, it is obvious that oxygen is the most logical element to choose for the combination. The reaction between these two elements is endothermic, so the question then arises: Can we convert nitrogen into its oxides with an expenditure of energy low enough to make it of practical value, and then utilize these oxides in the production of some commercial material.

The chief developments along this line have been based upon the principle that the reaction between nitrogen and oxygen is a thermal one, and that the union can only be accomplished through a supply of energy in the heat state.

$$N_2 + O_2 \rightleftarrows 2NO - 43{,}200 \text{ calories}$$

An examination of this equation will show that the volume of gas at the beginning of the reaction is the same as that at the end, and consequently the position of equilibrium of such reaction would be uninfluenced by the pressure under which it is carried out.

The temperature at which this reversible reaction is maintained, however, has a very marked influence upon the equilibrium position on account of the different velocities with which the two reactions proceed, the amount of chemical action being proportional to the active masses of the substances reacting*, that is

$$K = \frac{NO \times NO}{N_2 \times O_2}$$

K being the equilibrium constant for the temperature at which NO, N_2, and O_2 grams of nitric oxide, nitrogen, and oxygen respectively are present. This constant depending upon the temperature in accordance with the equation

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*Guldberg-Wasge Law of Mass Action.

$$\frac{d \log K}{d T} = -\frac{\Delta Q}{2 T^2}$$

where ΔQ is the energy change in the system and T the absolute temperature†, enabled Nernst to compare the observed and calculated values of NO—.

Temperature	% NO Observed	% NO Calculated
1811°	0.37	0.35
1877°	0.42	0.43
2033°	0.64	0.67
2195°	0.97	0.98
2580°	2.05	2.02
2675°	2.23	2.35
3290°	......	6.00
3712°	......	8.00
4141°	......	10.00

According to the above table, if air is heated to 2580° C., 2% of its volume will be nitric oxide, while if the temperature be lowered to 2200° C. one-half of the nitric oxide formed at 2580° is dissociated, or the air contains only 1% NO.

These reactions, however, require time as no energy change can be made instantaneously. Jellinck gives the following tables from experimental data, the first showing the time necessary to produce one-half the amount of nitric oxide as given by Nernst's equilibrium constants; the second, the rapidity with which nitric oxide dissociates to the extent of one-half its volume.*

TABLE I

Temperature	Time
727° C.	81 years
1227° C.	30 hours
1427° C.	1 hour
1627° C.	2 minutes
1827° C.	5 seconds
2027° C.	0.2 second
2227° C.	0.01 second
2627° C.	0.00003 second

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†See Nernst "Application of Thermodynamics to Chemistry."

*From Norton's "Utilization of Atmospheric Nitrogen."

TABLE II

Temperature	**Time**
627° C.	123 hours
827° C.	10 hours
1027° C.	44 minutes
1227° C.	3 minutes
1427° C.	15 seconds
1627° C.	1 second
1827° C.	0.07 second
2027° C.	0.005 second

From these data it is seen that above 2500° C. the reaction becomes almost instantaneous, yielding 2% NO at this temperature; also, below 1000° C. the dissociation becomes practically negligible.

It is apparent from this that for a method of fixation based on this physico-chemical phenomenon, the mixture of nitrogen and oxygen must be heated to an extremely high temperature, and then cooled as rapidly as possible to minimize the reduction of the nitric oxide formed.

As the temperature falls below 600° C. the oxidation of NO to NO_2 begins. Below 140° C. NO_2 commences to polymerize into N_2O_4, together with a slight formation of N_2O_3—

$$NO + NO_2 = N_2O_3$$

When ordinary temperatures are reached the gases arrive at an equilibrium condition where NO, NO_2, N_2O_4, and probably a small amount of N_2O_3 are all present with the free oxygen and nitrogen of the air. The percentages of these nitric oxides, however, are so small that a complete absorption is difficult.

The absorption process now employed permits the cooled gases to come in contact with water, the following reactions occurring:

$$N_2O_4 + H_2O = HNO_3 + HNO_2 \quad (A)$$

$$NO_2 + NO + H_2O = 2HNO_3 \quad (B)$$

The nitrous acid found here decomposes to nitric acid and NO according to

$$3HNO_2 = HNO_3 + 2NO + H_2O \quad (C)$$

More NO now oxides to re-establish the equilibrium condition. Consequently there is a cycle of changes and the absorption must be repeated at least four times in order to obtain 90% of the NO originally present.

After this absorption in water, the gases are usually conducted into alkaline solutions where the following reaction takes place:

$$4NO + 2NaOH = 2NaNO_2 + N_2O + H_2O$$

This formation of N_2O means a loss of combined nitrogen as nitrous oxide is unable to take up oxygen under absorption conditions.

For the practical application of the fundamental principles outlined above it is apparent that the oxidation operation can be carried out successfully only at the temperatures available with the use of the electric arc. Among the several processes developed on this "arc" method, the most promising are the Birkeland and Eyde, the Schonherr, and the Pauling. These differ from one another only in the methods for drawing the arc and producing the sudden cooling of the treated gases. Excellent descriptions of these processes can be found in other papers, so it is not deemed essential to rêpeat them here. However, it is well to analyze the results obtained in order that we may make comparisons with other methods as to the energy consumption and operating expense.

The dominating factor is, of course, the amount of "fixed" nitrogen finally obtained in a usable form against the energy expended. The concentration of "fixed" nitrogen—usuall yexpressed in volume percent. NO— in the gases effluent from the reaction chamber also is a very important factor, as the efficiency of the absorption process is dependent upon it.

The most reliable data on the present normal output of the best types of these furnaces give the following figures:*

	Grams of nitric acid, HNO_3, per K.W.H	**Concentration Volume percentage of NO**
Birkeland & Eyde	70	2.0
Schonherr	75	2.5
Pauling	60	1.5

Although the Schonherr furnace gives higher yields, it is constructed in units of smaller power capacity and consequently the installation and operating expense is increased, making it from a pecuniary standpoint practically on the same paying basis as the others.

On the assumption that all the nitric oxide obtained from these processes is finally in the form of nitric acid we are able to compute the absolute efficiency of the fixation.

$$N_2 + 1\tfrac{1}{2}O_2 = N_2O_5 - 12000 \text{ calories}$$

***From Norton's "Utilization of Atmospheric Nitrogen."**

Considering the acid as anhydride, N_2O_5, and that this is the direct product of the reaction chamber, we have from the above, that for every 108 grams of N_2O_5 produced, it is necessary to supply 1200 calories. According to the following:

$$N_2O_5 + H_2O = 2HNO_3$$

108 grams of N_2O_5 is equivalent to 126 grams of HNO_3, or the energy of formation of HNO_3 is

$$\frac{1200}{126} = 9.54 \text{ calories per gram.}$$

The heat equivalent of a kilowatt-hour being 0.86×10^6 calories, the efficiency of a process giving X grams of HNO_3 per kilowatt-hour will be

$$\frac{9.54 \times X}{0.86 \times 10^6} \times 100\%$$

$$\text{or efficiency} = 11.1 \times X \times 10^{-4}\%$$

From this it is seen that the absolute efficiency of the best yielding arc process is only 0.84%.

Besides the efficiency being low, the chief objection to the arc process has been the necessity for the large oxidizing chamber in which the nitric oxide is converted into a mixture of the higher oxides and the mammoth absorption towers in which these oxides are permitted to act on water giving nitric acid. The cost of installation of such a plant makes it unable to compete with other sources of fixed nitrogen unless the cost of power is extremely low.

Other methods for effecting the direct oxidization of nitrogen by electrical means have been experimented with, but as yet have not proven to be commercial processes. They may be classed under the heads of the spark discharge, the silent discharge, and electrolytic action. All these researches have been based upon the fact that there also exists an electrical equilibrium—or better, an "energy" equilibrium—between nitrogen, oxygen and nitric oxide. If such a process could be developed as to permit the direct transformation of electrical into chemical energy, a very marked increase in efficiency would result as the majority of energy loss in the arc or thermal process is due to radiation and heat loss in the escaping gases, together with the "energy drop" in the oxidizing and absorption chambers.

Turning now from the oxidization of nitrogen the next least costly element to be used as a basis of fixation is hydrogen, especially when it can be used in the form of producer gas or some other such mixture, the result of the combination being ammonia. Contrary to the reaction between nitrogen and oxygen, this reaction is exothermic and also is accompanied by a 50% decrease in volume.

$$N_2 + 3H_2 \rightleftarrows 2NH_3 + 23{,}900 \text{ calories}$$

From this it is seen that the favorable conditions for the reaction are increased pressure and decreased temperature. A catalytic agent, however, is necessary, so several methods have resulted, differing from one another only in the degree of pressure and temperature and the catalytic agent used.

The Haber process is probably the best known of these, and consequently will be briefly outlined to illustrate the method. A mixture of three volumes of hydrogen and one volume of nitrogen at a pressure of at least 150 atmospheres and a temperature of 500° to 700° C. is passed over powdered uranium as a catalyzer. This causes a transformation of from 2 to 6 per cent. of the nitrogen to ammonia, which is recovered from the apparatus by condensation. The remaining uncombined gases are then returned to the cycle. From the ammonia thus obtained nitric acid may be produced if this is the required product.

The advantages of this process are the low power consumption and the possibility of working in small plants. The disadvantages, which I understand have ceen chiefly overcome, are the difficult engineering problems involved in the use of 150 atmospheres pressure and temperatures from 500° to 600° C., the high repair and renewal costs, and the necessity of liquifying not only the air to produce nitrogen, but also the "water gas" to produce pure hydrogen-oxygen, hydro-carbons and sulphur being fatal to the catalyzer.

Considering the possibility of making nitric acid from ammonia produced by this process, there is but very little data on which to base an assumption. However, if the various estimates contain the least degree of accuracy, the conversion of synthetic ammonia into nitric acid is altogether feasible.

Next to oxygen and hydrogen, carbon is probably the cheapest element with which we can form compounds of nitrogen. The solution has been attempted, however, not with pure carbon alone, but with a mixture of carbon and a carbide or carbonate. As an example, let us consider the Bucher process. Its essentials consist of the heating of a mixture of two parts of coke, two of iron, and one of sodium carbonate to a temperature of 800° to 900° C. and passing nitrogen through the mass. Under these conditions sodium cyanide is formed.

$$Na_2CO_3 + 4C + 1\frac{1}{2}O_2 + N_2 =$$
$$2\ Na\ CN + 3\ CO_2 + 61{,}500\ \text{calories}$$

The iron acts as a catalyzer. Sodium ferro-cyanide is formed if steam is blown through the mass.

$$6\ Na\ CN + Fe + 2\ H_2O = Na_4\ Fe\ (CN)_6 + 2\ NaOH + H_2$$

As far as chemical problems are concerned, the details of the process are solved, but the mechanical construction of a furnace to withstand these conditions has not been obtained.

The cyanide process consists in the treating of calcium carbide with nitrogen in the electric furnace.

$$CaC_2 + N_2 = Ca\ CN_2 + C$$

It is very simple to convert this cyanide into ammonia by the exothermic reaction.

$$Ca\ CN_2 + 3H_2O = 2\ NH_3 + CaCO_3$$

Due to the explosive nature of the calcium carbide and various difficulties encountered in its manufacture, this process has not gained the popularity of processes of greater fixation cost.

Fixation has also been attempted in the form of nitrides of aluminium, silicon, boron and magnesium in the electric furnace. The cost of manufacture seems at present to be too high to allow them to compete successfully with the products of other processes.

THE USE OF IRON WIRE VS. COPPER FOR TRAIN DISPATCHING CIRCUITS

By STANLEY RHOADES, '16

The subject of iron wire vs. copper for train dispatching circuits will be limited to the use with telephones in this discussion because the telegraph is rapidly becoming obsolete for train dispatching and few problems arise in connection with the choice of wire for such telegraph use.

A telegraph dispatching circuit should be designed to give continuous communication between the dispatcher and the way stations with a volume of transmission well within the limit required by safety in handling train orders. This statement includes two important requirements; viz, continuous service and sufficient volume of transmission. These two are interlinked in the construction and material of the physical line or "outside plant." The volume of transmission is controlled more by the "inside plant" or telephone instruments than is the continuity of the service.

The choice of wire to be used depends upon whether the pole line is built or is to be built. If the line is already built, the distance between poles is settled and makes necessary the use of wire strong enough to support itself with a coating of ice, perhaps one inch in diameter, with a wind pressure due to a forty or fifty mile gale, and with the temperature 20 degrees below zero. This condition of ice, wind and coldness occurred in the territory just west of LaFayette during the second week in January of this year with disastrous results. Some of the wires broke in many places due to the lack of strength. The poles were 41 to the mile, which is relatively wide spacing compared to 53 or 70 per mile used in some places.

If the pole line has not been built and can be chosen by the engineer designing the plant, he can choose a guage and kind of wire that will give the required transmission and space the poles properly to carry the wire without danger of wire breaks under severe ice, wind and cold weather stresses. In most cases, the railroad telephone engineer has the pole line already provided and must put up a satisfactory line on it.

Another condition sometimes confronts the engineer: the pole line and the wire are both in use and must be adapted to telephone train dispatching. It is in the latter case that the use of iron wire for such service is sometimes permitted. I say "permitted" because there is much hesitancy displayed by the executives in deciding to use iron wires. The objection is that iron wire deteriorates rapidly as compared with copper and develops high resistance at joints that are made in the line at times when it is not economical to attempt soldering them when splicing, for instance, during storm trouble and zero weather. The high resistance of the wire, even when new, has resulted in poor transmission in the past on comparatively long lines and has created prejudice against iron.

Distance is a considerable factor in the problem. One of the eminent telegraph engineers, who was formerly a telephone engineer, is on record as believing ninety miles the limiting distance for No. 8 BWG iron wires which is the common size in use on railroads. It is necessary to differ with him due to the fact that he is considering previous standards of telephone sets, commonly considered of maximum efficiency. Standards of one year due not hold good in very many succeeding years. It is seldom safe to say what is not being done can not be done. We may say 150 miles is the limit of transmission distance for train dispatching on No. 8 BWG iron wires today and within a short time the distance may double.

The problem of the train dispatching circuit differs from the ordinary commercial transmission problem because there are a number of stations that can listen in on a dispatching circuit. The railroad telephone set for dispatching was designed with the belief that never more than 10 or 15 stations would listen in on the circuit simultaneously. In recent months it has been shown that perhaps 40 or 50 stations listened in at once. The result was that even with No. 9 B & S copper wires it was almost impossible to hear a station 150 miles. The impedance of the listening sets was not high enough. Increase of impedance has resulted in reduction of "bridging" losses to the point where 40 or 50 stations can listen in without transmission falling enough to be detected on a 150 mile No. 9 B & S copper line.

This same reduction in bridging loss has made possible the use of No. 8 BWG iron wire for a distance up to 150 miles under conditions which previously limited No. 9 B & S copper to that distance. I am unable to state at the present time what could be considered the present limiting distance for No. 9 copper because its range has been increased much beyond the present needs for dispatching. Within the past year, three circuits have been arranged, each 140 miles long, using existing No. 8 BWG iron wires, some of which have been erected as long as twenty years. The transmission has been satisfactory and in fact better than on No. 9 copper formerly used over the same division of the railroad. The remarkable facts observed are: that the average resistance of these wires does not exceed the values given by the manufacturers for the same gauge of iron wire when new; that the joints are secure enough to give almost negligible trouble from high resistance and consequent "noise;" and that through the same territory on the same pole spacing the No. 9 copper wires gave more trouble due to breaks during storms and cold weather.

In the future, these wires may rust and lose strength enough to become very troublesome, but at the present time when copper wire is high priced and needed in the manufacture of war necessities, it is evident economy to make use of the existing iron wires for telephone train dispatching.

The present railroad telephone sets, which are of the local battery type, are 5 to 10 miles of standard cable better than standard common battery sets. Train dispatching requires a grade of transmission estimated at no less than "18 miles," whereas commercia9l long distance is considered satisfactory at "28 to 30 miles." This indicates the added volume necessary for safety in handling trains.

No. 9 B & S gauge copper wire will give 20 miles transmission at least 250 miles. Railroad sets will increase this one-third, making approximately 330 miles. Copper wires give transmission relatively in inverse ratio to the resistance. Therefore copper wire at 13.5 ohms, which is the average resistance of No. 8 iron, would give "20 mile" transmission 110 miles.

Iron wire does not quite hold to the inverse ratio theory but approximates it closely enough to use this method for making quick estimates of transmission distance. It follows from this, and is checked by results, that No. 8 BWG iron, such as found on many existing lines, will give "20 mile" transmission.

In regard to cost, it is safe to say that the cost of more efficient instruments is infinitessimal compared to the increased cost of lower resistance line conductors.

It is the problem of the engineer to improve the instruments to such a poin that "20 mile" transmission can be obtained up to 225 miles on this No. 8 BWG iron wire. With the high impedance receivers the transmission on our average length existing No. 9 B & S copper circuits has been brought very near the point of "zero miles of cable;" in other words, no distance is noticeable and all stations on the lines sound as if they are in the same town. We will not be satified until the iron wire circuits closely approach this standard.

THE RECOVERY OF TOLUOL AND BENZOL FROM ARTIFICIAL GAS

By C. EARL LITTELL, CH. E., '11

On account of the small amount of space allowed for this article it will be impossible to go into the subject as fully as I should like, therefore, many engineering features and problems connected with the industry, as well as a great amount of interesting data and methods of analysis, must necessarily be omitted.

The recovery of the aromatic hydrocarbons from gas is not a recent process but has been highly developed in the past few years, especially in America. The principle employed at present by American gas companies and by-product coke ovens for the recovery of benzene and its homologues was made use of as early as 1859 by Vogel. To enrich fatty oils for illuminating purposes, Vogel washed or scrubbed coal gas with these oils. The practice of today is to wash the gas with an oil which is a good absorbent of benzol, toluol, etc. In America the oil generally used is what is known as "straw oil," while in Europe tar oil or creosoting oil is commonly used. Both are good absorbents. The gas is washed in a tower. The oil enters at the top in the form of a spray and is uniformly distributed over the top of the scrubbers. The gas enters the bottom of the tower and flows in an opposite direction to that of the oil, thereby bringing the gas with the least amount of light oil vapors into contact with the fresh oil. This process was put into successful operation in 1887 by F. Brunk, who is acknowledged as being the founder of the modern benzol recovery industry.

Straw oil is a petroleum product of about 0.88 specific gravity. The oil on straight distillation should not start to distill much before the temperature of 250° C. is reached and about ninety per cent should distill between 250 and 350° C. It does not contain any napthalene or pitch (as does tar oil) and should be practically free from members of the oleofine series, eight per cent being considered as a maximum amount allowable. It should have a low congealing point, being readily fluid at 4° C. and should not emulsify with hot water or steam. The fact that it does not contain any naphthalene or pitch gives it a decided advantage over tar oil, although the latter, with a boiling range of 200 to 300° C., makes an excellent absorbent.

Before scrubbing or washing the gas it is cooled to a certain temperature, depending upon its moisture and naphthalene content and the temperature of the wash oil.

The American practice is to enrich the scrubbing oil to about three per cent. Too low an enrichment involves a needless consumption of absorbing oil and steam, while too high an enrichment may allow the gas to pass through the scrubbers without complete removal of the benzol. From the scrubbing tower the enriched absorbent oil runs into tanks usually located beneath the scrubbers. The enriched wash oil is now pumped to the benzol recovery plant, where it is heated to drive off the hydrocarbon vapors. (About eighty-five per cent of the condensible hydrocarbon vapors belong to the aromatic series, being made up of benzene, toluene and the three xylenes. The remaining fifteen per cent consists of carbon disulphide, thiophene, naphthalene, pyridine and members of the oleofine series.) After being preheated by certain heat exchanges and economizers and finally heated to its maximum temperature by live steam in a superheater, the enriched oil enters the still. The still consists of superimposed chambers as found in any common distillation practice. The heated oil runs down through these sections while live steam is blown in the opposite direction. The benzol vapors are condensed in water cooled condensers. The light oil and water are separated by means of a separator; the former is run in an underground tank, although some plants have these above ground.

Brief mention was made above of heat exchanges. The H. Koppers Company, of Pittsburgh, who have done more than any other company in America to develop the toluol industry, have made improvements which have affected as great an economy of heat as possible in the cycle of gas treatment, distillation, and cooling, through which the oil passes. It is calculated that in their system the devices for heat economy reduce the steam consumption in distilling the enriched wash oil by more than eighty per cent.

After the light oil is distilled and separated from the absorbent oil, it is pumped into the rectifying still. This still is of large capacity and has a more elaborate dephlegmator than the crude still. The light oil is now separated into crude benzol, toluol, xylol, and heavy solvent. The benzol and toluol are distilled off by indirect heating with steam coils and the xylol and heavy solvent by admitting live steam. The residue in the still consists of a certain amount of wash oil containing naphthalene and other constituents. The presence of this wash oil in the crude light oil is in part due to mechanical means and in part to distillation by live steam. The naphthalene is removed from it and the wash oil returned and recirculated.

Although most small plants sell their products in the crude state, some of the larger plants further purify the benzol and toluol by washing with commercial sulphuric acid of 66° Be. strength. A heavy sludge will form, which separates, due to gravity, and is drawn off. The oil is then washed with caustic soda in what are termed agitators. These are large lead lined vessels with mechanical stirrers or mixing devices. The acid forms sulphonic acid salts with the members of the olefine series present, and certain phenoloid bodies. These so-called sulphonic acid compounds are of a resinous nature and are very dark in color, having a high boiling point. The greater part of these are heavy and insoluble in the light oil and separate out as mentioned above; some, however, are soluble and cause the benzol to have a reddish color, making it necessary to steam distil the benzol to get rid of them. The alkali neutralizes any of the sulphuric acid which might be present and also removes the phenols if present. After the benzol is washed and distilled, it should be water white and if properly washed, it will remain this color when shaken with sulphuric acid. This last distillation requires a very efficient dephlegmator column and products are easily obtained having a boiling range of less than two degrees.

Rapid development in the recovery of toluol has taken place in this country since 1914, although the recovery was common in Europe several years previous to this date. Our seeming backwardness was not due to lack of knowledge or talent, but to the lack of demand together with the abundance and cheapness of petroleum. In America, the recovery originated with the by-product coke oven people. In 1914 there were sixteen plants making light oil from coke oven gas and none from what is know as illuminating gas. The light oil recovered previous to that time was used principally as a gas enricher, only a small amount being worked up into pure benzene and toluene.

On account of the high prices created by the war, the toluol industry was stimulated and great extensions were made. Our foreign supply was stopped in 1915 and the munition business was gradually demanding more; consequently the prices for benzene and toluene became very attractive, chemically pure benzol selling for eighty cents and chemically pure toluol as high as seven dollars a gallon.

The first large modern plant for the manufacture of chemically pure products was put in operation in May, 1915. The total production of benzol products increased more than one hundred per cent that year, over 22,000,000 gallons being produced. In the first part of 1917, there were about forty benzol recovery plants in operation with by-product coke plants, having a capacity of 30,000,000 tons of coal per annum. At that date other gas companies (besides coke oven plants) manufacturing gas for city distribution, such as Syracuse, N. Y., Des Moines, Iowa, Philadelphia, Pa., and Washington, D. C., were also recovering toluol from their gas. The first three of these are owned and operated by the United Gas Improvement Co., of Philadelphia, who designed their own toluol plants, while the last is a locally operated company using a toluol plant installed by the Koppers Company.

On account of most illuminating gas companies having to keep their gas at a certain photometric or calorific value, they generally return the benzol and xylol, selling only the toluol. Sometimes it is necessary to purchase extra benzol for enrichment.

Since the United States has entered the war, there are a great many city gas plants preparing to recover the light oil from their gas. Standards for the gas are also being lowered in order to assist them and thereby aid the United States to prosecute the war.

On January 1, 1917, benzol was selling at fifty-five cents a gallon and toluol at one dollar and seventy-five cents to two dollars and a half. On January 1, 1918, there were no prices quoted as the Government is taking all of these products and there is very little to be had on the open market.

Quite a few people, no doubt, are asking what will become of this wonderfully developed industry after the war is fought and won. There will still be enough demand for these products to pay to continue the operation of these plants. In the explosive field we make the powerful explosive T. N. T., trinitrotoluol and tetranitroaniline. These no doubt will be used more in the future for blasting than in the past, their superior qualities for this purpose having been demonstrated by the war. In the future the United States will no doubt adopt a different military policy to what she has in the past, and as the lasting qualities of T. N. T. permit it to be stored without deterioration, a great deal will probably be manufactured owing to more military training.

Likewise, as in the recovery of toluol, the war will cause an increase in chemical industries and, therefore, insure a greater market for benzol to be used in the manufacture of synthetic products. Benzol is used in the production of nitro-benzene, aniline and its derivatives, and synthetic phenol. Due to the increase in production of the various condensation products of phenol and formaldehyde, the manufacture of synthetic phenol may be considered as a very important outlet for benzene. From toluol we obtain benzaldehyde, saccharine and banzoic acid and from meta-xylene some important dyes and also toluic acid.

The question of using benzol as a motor fuel is of no mean importance. Before the war Germany used over fifty per cent of her benzol production in the operation of internal combustion engines. J. S. Critchley, president of the British Institution of Automobile Engineers, has made the statement that the carburation of benzol presents no difficulties and that in actual practice the material gives an increase in mileage of about twenty per cent over gasoline, affording at the same time twelve to fifteen per cent more power. A series of tests made in 1913, at Brooklands, England, showed an average of five miles increase per gallon.

Mr. F. W. Speer, Jr., Chief Chemist of the H. Koppers Company, states in a paper read at the New York meeting January 12, 1917, of the American Institute of Chemical Engineers:

> "The demands of the automobile industry alone are so great as to preclude the possibility of any destructive competition between benzol and gasoline * * * * * The benzol recovery plants now in course of construction, together with those already operating, will make an annual production of about fifty million gallons of benzol. There are now over two million automobiles in operation in this country, so that the contemplated benzol production would give each machine about twenty-five gallons. If all the coke that the country now requires were coked in by-product ovens with benzol recovery apparatus, we should expect a total benzol production of about one hundred and ten million gallons or fifty-five gallons per machine. This total benzol would be less than half the amount of gasoline and naptha exported in 1915."

Another phase in the use of benzol is its employment in the manufacture of paints, varnishes, stains and lacquers. It is used extensively in the cleaning industry; in the extraction of fats and greases; as a solvent for rubber and for the manufacture of artificial leather and insulating materials.

THE MANUFACTURE OF TELEPHONE CABLE SHEATH

By D. P. Craig, '12

The present process of manufacturing lead sheath for telephone cable is by the extrusion of the lead under high pressure around the cable core. This principle of extrusion through a die under pressure is a very old one, starting out with a simple hand screw press and a round die forming lead rod. The evolution of the present hydraulic extrusion presses from such a small beginning has been gradual and has required the work of many engineers and inventors. And at present changes are being tried out in search of further improvements.

The first patents on record were taken out in England in 1797, with lead extruded in round rods. One of the early designers was J. Robertson, who in 1847 turned out a machine for extruding lead sheets. One of the present presses used to great extent in lead-covered cable manufacture is the Robertson press.

The first record of the use of the extrusion press for telephone cable was in British Patent No. 10799, obtained by William Young and Archibald McNair, manufacturers and merchants, of Paisley, on August 4, 1845. This patent covered an improved method of manufacturing electrical conductors "formed of one or more copper, iron or other metallic, or mixed metallic wires." The wires were covered "with threads in a plaited or braided form by means of a braiding machine." Having been covered, they were wound on reels and then unwound from the reels through a lead press, first passing through a cistern of molten pitch. Two methods of lead-press operation are described; "containers" and "die blocks" are fully illustrated; the consistency and temperature of the lead defined, and suitable methods of applying heat to both the insulating material suggested.

The patentees claim "the construction and manufacture of the electrical conductors by the employment of machinery having a tubular mandril or hollow rod through which wires may be drawn, while the lead or other soft metal tube is forming, by pressure between a core and die, such wires being at the same time imbedded in pitch or other non-conducting material." (British Specification No. 10799, 1845.)

It is remarkable that this is the principle which is generally used today, although other methods have been tried and used since. At one time the lead tube was made and then the cable core was drawn in the tube.

The Robertson press is one of the latest forms of extrusion presses. The base of the press, a heavy steel casting, contains the water cylinder, which is copper lined. At the top of the press, another heavy steel casting is supported and held rigid by four steel columns. The water ram is free to move vertically in the waetr cylinder, depending upon the direction of the water pressure. The die block is placed on the water ram and above the die block is the lead cylinder bolted to the bolster plate on the water ram. The lead plunger is bolted to the top of the press.

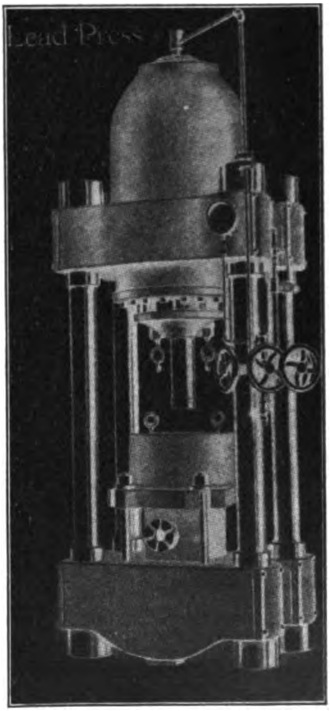
Associated with the press is a mixing and melting kettle which is a kettle of 12,000 lbs. capacity over a gas burner. The metal mixture is kept at a temperature of 600° Fahr. and is constantly stirred. The metal is drawn off from a valve at the bottom of the kettle and runs down a trough into the lead cylinder of the press. As the metal is used the kettle is supplied with an equal amount of solid metal in the form of pigs. This solid metal is loaded into the kettle by hand.

The press is driven by hydraulic pressure from a four-cylinder pump. This pump is driven by a four-speed motor controlled by the operator at the lead press. The speeds of the motor vary from 300 to 900 r.p.m. and the horsepower from 12 to 35. The smaller the cable, the slower the travel of the water ram and consequently the slower is the motor speed used.

The pump has a heavy fly wheel on the draft to absorb any shock and to keep the pump working evenly under all conditions. The four plungers are driven by eccentrics on the shaft and are all one quarter of a revolution apart. With each up-stroke the inlet valve is opened and water is drawn in, and with each down stroke the water is forced out through the outlet valve. With the high pressures used the plunger must be packed without a leak.

The pressure line from the pump enters a controlling valve handled by the operator at the press. By means of this valve the pressure can be directed into the bottom of the cylinder forcing the ram upward, or into the top of the cylinder forcing the ram downward. In this latter case a by-pass valve is also opened, allowing the water below the ram to escape very rapidly.

Three packings (leather) are used and the top packing is held in place by the gland at the top of the cylinder. The middle packing is V-shaped and is fastened to the shoulder near the bottom of the water ram. The bottom packing is cup-shaped and fastened to the bottom of the ram. These packings stand a water pressure of 6,000 pounds per square inch and when they wear out the ram is removed and new packings set in place.



The die block is made of chrome steel forging. The top and bottom halves bolted together have a straight bore 4 7/16″ diameter, which holds the core tube. Core tubes are tubes of steel with the outside diameter the same to fit the bore of the die block. The inside diameter varies in the different core tubes according to the diameter of the cable core the tube was designed for. The core tube is rounded down to a thin nose at the forward end. This nose, when the core tube is in place in the die block, sets forward in the die with enough annular space between the core tube and die to allow lead to flow through forming sheath of the required thickness. The core tube is cigar shaped and resembles in appearance a 4½″ shell.

The die is a ring with outside diameter 4 7/16″ for the 4 7/16″ die block and the inside diameter is the same as the outside diameter of the lead sheath formed. The thickness of the sheath is regulated by adjusting a nut which holds the die in the die block. If the nut is loosened, the pressure of the lead forces the die forward, increasing the annualar space between the core tube and the die, thus increasing the thickness of the sheath. If the nut is tightened the opposite results are obtained and the sheath is made thinner.

The cylinder is a hollow cylinder of cast steel with a groove cut out around the bottom to fit over the hub of the die block, insuring a good grip. Inside of the cylinder is pressed a nickel chrome steel bushing 10 inches inside diameter and about 3 inches thick. This bushing undergoes very severe usage as cooling water circulates though a helical groove cut in the cylinder around the bushing; and the inner surface of the bushing is in contact with the molten metal. In addition to the strains caused by the temperature range is the pressure on the metal.

The press operation is briefly as follows: The water ram is backed down until the lead plunger is clear of the lead cylinder. A charge of molten metal (700 pounds) is run from the kettle into the cylinder. The water ram is moved up until there is a total pressure of 200 tons on the ram; this pressure is kept constant until the metal in the cylinder has just passed the solidifying point, at which time the extrusion begins. The pressure of extrusion varies slightly, depending upon the size of the cable, the temperature of the die block and like conditions, but it usually is approrximately 2000 tons on the ram. The lead is forced downward from the cylinder through the opening in the top of the die block into the die block pocket, which is the space cut in the block around the nose of the core tube. At this point the lead is turned forward and passes out of the die block between the core tube lip and the die, in the form of annular sheath. As this sheath extrudes it pulls with it the cable core.

The cable core is fed into the back of the die block from a reel and is pulled through by the lead sheath. The lead-covered cable thus formed is taken up in front of the press on a regular cable reel.

The field of the mechanical engineer in lead press work is to follow up the work of those engineers and designers who have gone before. He should endeavor to improve the presses or other machinery by changes in design; to make working conditions better; to increase the output by some method of decreasing or eliminating the cooling period; to reduce costs by use of better materials in the pump or press. He should study the action of the lead and try to increase the quality and durability of the sheath formed, by experimenting with different mixtures of metals. A study of the effect of temperature on the action of the lead in the die block should also be made. There are many roads to improvements as the press of tomorrow is sure to be different from the press of today.

INDUSTRIAL ENGINEERING AT PURDUE

By J. E. Hannum

The cry for men in all lines of activity is nation-wide. Particularly is this true in industrial enterprises. The Government has asked Industry to supply the many material requirements of her fighting forces across the sea, and Industry is responding nobly and loyally. Industry has thrown open her workshops and factories to the needs of the Government, and is putting forth every effort to do her "bit," which, as prime mover, is all-essential. That she is prime mover is clear upon a little reflection. She makes possible the training of troops at home by building cantonments; she transports them to the field of battle with her ocean craft; she equips them, feeds them, and relieves their pains and sufferings while upon the battle field. To do all this, Industry is being pushed to her maximum capacity.

The very fact that this appealing call for aid has been made, has caused managers everywhere over the country to ask themselves how they are going to be able to meet the unusual conditions brought about by this world war. Problems of every sort and character, which tax to the utmost the managerial ability and technical knowledge of the executives of industry, must be solved over night—problems arising from conditions and causes that never existed before. The solutions of these problems are not found in technical literature or in reports of research and investigation along engineering lines. They are entirely present-day and must be met by the common sense and judgment of executives which have been brought about by years of practical experience and an accumulation of general knowledge of industrial methods. The Government appeals to Industry. Industry in turn depends upon the guidance and controlling force of her directors, to be able to meet this demand.

Less than a quarter of a century ago, there was established a new science, namely, the Science of Management. The introduction of this science into business methods was made possible by the unceasing energy and detailed investigations of its founder, Dr. F. W. Taylor. Since then its growth has been rapid and its influences have been far-reaching; no longer is it considered as a new, untried science. Too many important concerns throughout the country have definitely determined the worth and value of the improved methods of management as outlined by the

Principles of Scientific Management. It has favored the employer and the employee alike; above all, it has entered the field of business enterprise as the mediator between the ever necessary and conflicting forces—capital and labor. But never in the life of this science has there been such an opportunity as today for it to demonstrate its true worth and unquestionable value. Unfortunately, this opportunity has been given by a horrible conflict demanding human lives, but it is here and must be met. It is by the Laws of Scientific Management—the Principles of Industrial Engineering—that the executive must find assistance.

Industrial problems of today are difficult of solution because they are unusual and exceptional. Greatest of them all, however, is the question of shortage of men, and being greatest it is likewise largely responsible for them all. Broadly speaking, such results as these have been produced by the demands of the war, and it can be seen that the influencing factor, either directly or indirectly, has been the shortage of labor.

1. A great many men have been called from industrial pursuits into the service of their country. This temporarily crippled production, but immediate adjustment was made by enlisting woman labor to fill the vacancies.

2. The increased consumption of materials for war purposes, and the inability to meet this at once, has resulted in a temporary check to production. This is gradually and effectively being adjusted by the efforts of various Federal departments.

3. Likewise the transportation of materials and supplies affected directly or indirectly the output of plants all over the country. Adjustment is also being accomplished in this by Federal Administration.

4. Because of the urgent need for war munitions and war equipment of all kinds, plants have been required to speed up production so as to obtain a maximum output.

What is the result of this brief summarization of influences that are being brought to bear upon industrial enterprises? The four points, mentioned above, show clearly that industry is attempting to carry a peak load under such enormous handicaps as labor shortage, inexperienced workmen, scarcity of materials, delayed transportation, and, in some instances, public criticism. Can the industrial establishments of the United States be expected to do in one year what has been brought about in Germany in the last fifty years?

The underlying cause of all these abnormal conditions is the great reduction in the laboring force made necessary by the call to service. Not only has this call reduced the number of workment for the activities of the shop, but it has also taken men who have been directing—men performing the duties of managerial activities. It is a well-known fact that the more authority that an individual has in an organization, the more difficult it is to replace him with another. Many industrial organizations at present are mere skeletons of what is actually required. The different parts of this weakened framework are held together almost entirely by the loyalty and unselfish resignation of energy to the cause of humanity shown by those who are left. The functions of the various parts of such organizations must be distributed among fewer men, but they must still be carried on. It is evident, then, that it is of great importance that men receive training along such lines as will equip them to complete the personnel of the organizations directing industry.

How is Purdue University equipped to meet this present-day need? A few years ago a course in Industrial Engineering was begun, in a way not at all presupposing, as a Senior elective in the School of Mechanical Engineering. Since that time it has grown slowly but steadily until at the present time it is a full Senior option. There are six lines of study required by those taking the option:

1. A general course in the Principles of Industrial Management, including consideration of Factory Location, Design and Construction of Factory Buildings, Factory Planning, Handling Material, Classifying and Indexing, Time and Motion Study, Specialization, Standardization, Types of Ownership, Organization Control, Wage Systems, Methods of Planning Department, Purchasing Department, Stores and Stock Department, Labor Problems and Labor Unionism, Factory Legislation, Welfare Work, and Industrial Education.

2. A special course in Heating and Ventilating problems as met with by the Works Manager.

3. The designing of lighting systems for industrial plants and the study of modern Factory Illumination development.

4. A course covering the essential principles of Cost Accounting with an introduction to the fundamentals of Bookkeeping.

5. A series of lectures on Factory Sanitation, Hygiene and First Aid.

6. Industrial Design, which is the solution of practical problems as met with by local concerns.

Further than this the theses prepared for the Bachelors' Degrees must be of a practical nature.

During the brief time that this complete course has been administered, many problems of importance to industrial concerns have been solved. A review of those which have been accomplished in the last two years will be presented here, since it is during that time only that the author has come in contact with the work.

The Sanitary Metal Basket Company of LaFayette, Ind., manufactures delivery baskets for grocerymen. These baskets are made from sheet metal, the various parts being cut out and put together over a form. The company contemplates building a new factory, and the problem presented was to make an investigation from which could be determined the location of departments and the proper placing of equipment. To do this it was necessary to study the different steps in the process of manufacture in order to find out the exact sequence of these steps. Detailsd time studies were taken in order to determine the necessary number of machines neded in th sequence to keep the prime movers busy. From the data thus obtained it was possible to determine the exact number of machines and workmen required to turn out any given product.

There are various sizes of these baskets made. It was desired to know accurately all of the items of expense entering into the complete cost of production. These items were divided into direct material, direct labor, and overhead charges or burden, and were arrived at as follows:

1. All direct labor charges were obtained by establishing a standard time schedule and by knowing the various rates of pay of all employees.

2. The material charges were obtained by calculating by exact measurement the amount of raw material entering into the finished product, and by reference to invoices of material for prices.

3. The items of burden expenses were easily obtained from the expense account of preceding periods. The distribution of this expense, however, was a more difficult problem. Since the main item of cost is material, it was decided to allot the overhead expense to the various sizes as a prorated amount in accordance to the amount of direct material used in each size.

4. An accurate schedule of selling prices was then established by adding a prorated amount of general administrative expense and a pre-determined necessary profit.

Appella Juice is manufactured by the National Fruit Juice Company of LaFayette, Ind. This juice is made from crushed apples, and the steps in the process involve the unloading of apples into bins, the picking, crushing and pressing, secret process in the sterilization of the juice, and the drying of the pomace, which is a by-product.

The solution of the problem was the placing of all equipment so that the material would be handled as little as possible. It meant the proper location of bins, conveyors, hydraulic presses, pickers, crushers, pumps, accumulators, transfer tracks, tanks, and a large evaporator.

The Barbee Iron Works of LaFayette, Ind., has offered some interesting problems, important of which was the design of a complete lighting system for the entire plant. This system as planned has later been installed almost entirely in accordance with the specifications as outlined by the students. At a later date, equipment layouts for two departments making special bent wire products were drawn up. Recently a thirty-day test has been conducted in the Tinning Department of this company. The purpose of this was for the information of the Cost Department. It meant the keeping of accurate records of all finished product that passed through the Tinning Department during the time of the test. To determine the quantities of materials used by the department in tinning all the different products, accurate weights had to be obtained of all these products before cleaning, after cleaning and after tinning.

The Diamond Chain and Manufacturing Company, of Indianapolis has likewise made it possible for the men taking the course to come in contact with actual problems as presented by industrial concerns. The work there has been along two entirely different lines, first, a study of the Tumbling Department, and, second, a twenty-hour test to determine the most efficient speed to run automatic screw machines. Both of these investigations brought out interesting and useful facts.

The Rockwood Manufacturing Company of Indianapolis desired time studies to be taken in order to revise the bonus system of wage payment which has been in use for a number of years. Since the time of installation many changes have been made and many new processes have been introduced so that it was necessary to break up the operations on each line and style of product into the elementary parts. By detailed time study of each elementary operation a standard time for doing that operation was established.

By far the largest problems undertaken during these two years have been the Shop Layouts as prepared for the Monon Shops at LaFayette, Ind., and the collection of data for a Complete Cost System at the Indiana Wagon Company's plant, also at LaFayette. Both of these represent the work done in Industrial Design during the last two years and each one covers a period of one year.

In the year 1916-17, the entire class of thirteen men were set to work to design a complete layout of the Repair Shops of the Monon Railroad. The development was in accord with ideas and plans of the officials of the company. It was necessary at the start to collect a great deal of data as preliminary work. This included complete floor plans of all departments, showing the location of all windows, doors, passageways and production equipment. In addition, layouts were made of all service equipment as the heating system, the lighting system, and the industrial railway system.

The next part of the work was the building up of route charts to show the exact path of every part as it passed through the shops. This was particularly hard to do since a repair shop presents an intricate problem and since all the necessary information had to be obtained by interviewing the foremen. A get-together meeting was held one evening in the rooms of the West LaFayette Club for this purpose. The route charts prepared were the basis of all the work which followed.

After carefully studying the existing conditions, new layouts of all departments were made to take care of contemplated future expansion and all old equipment, together with what new equipment was necessary, was located on the new layouts. The floor plans completed, new route charts were made showing the future paths of all parts through the shops. As far as possible all equipment was so placed that the routing of each part would not retrace itself, but would go straight through from the source to the final assembly. The exact distance traveled by each part was measured both according to the old layout and the new, to show the gain in time and expense of handling accomplished.

Incidental to this work were a great many investigations along different lines. For instance, the records for a period of five years were studied to determine the average length of time and cost of shopping of the different types of locomotives, together with a detailed analysis of the frequency with which certain parts needed repairing. In addition, methods of handling material, the care of equipment, the storing of all materials, checking system for tools, and provisions for the care and upkeep of tools were outlined. Altogether the final report as submitted covered many details and lines of investigation.

During the present year the Indiana Wagon Works has presented a problem of timely interest and importance, i. e., the establishment of a Cost System. The entire class of seventeen men have worked on the problem during the time they have had scheduled for Industrial Design. A great amount of information had to be collected of which no records had been kept and the officials and foremen cooperated in every way possible.

The development of this problem as the work progressed naturally divided itself into four parts:

1. The collection of preliminary data.
2. The classification and study of the data as obtained and the making of floor plan layouts and route charts.
3. The taking of time studies.
4. The labor and material cost analysis.

It was first necessary, in order to become thoroughly familiar with the various methods of manufacture and the type of product, to have available a complete layout of the entire plant. Consequently, drawings were made showing the location of all departments, machines, benches, storage spaces, lumber sheds, and dry kilns. An assembled wagon was gone over by one of the foremen so that everyone could familiarize himself with the names and location of the parts of the wagon.

The class entertained the foremen on two different evenings and at these meetings information as to the various operations performed on the different parts and the sequence of these operations was obtained together with a great deal of other required data.

With this information at hand, floor plan layouts of every department were made, and route charts showing the path of each part were drawn. The names of the various parts of the wagon were listed and likewise a classified list of all equipment was made. A mnemonic symbol system was devised for all departments, production centers, and wagon parts. Forms were designed to take care of tabulations of data.

Then followed the collection of operation time studies of each part. A schedule of operations by machines and another schedule by parts were worked out from which were designed time study cards. On these were placed all information as collected. The time elements thus obtained were used as the basis of the final cost sheets.

Cost sheets for all the direct material entering into the wagon were prepared from past records of material costs. These listed the dimensions, quantity, quality, unit price, and cost per part of all direct material. Cost sheets for all direct labor were likewise prepared.

As this edition goes to press, a final analysis of all data and information is being made to arrive at a definite cost of all direct labor and material. Due to lack of time no attempt has been made to take up the consideration of burden, but it is hoped that at some future date the development can be carried further.

Space allows only a brief outline of the work that is being accomplished along the lines of investigation as set forth in this article. The results as obtained by the careful study and solution of all these problems have been highly satisfactory. It is the attempt of those administering the course to make it as practical as possible, in order that those men who leave Purdue are better able to understand the many intricate phases of industrial work and will make better managers when they reach those positions of importance.

STEVENS RIVER STAGE RECORDER

By. M. W. Furr, '13

The civil engineering department of the Kansas State Agricultural College, Manhattan, Kansas, has recently purchased and installed a Stevens Continuous River Stage Recorder in order to obtain a complete record of the stages of the Kansas River.

Stevens Long Distance Continuous Water Stage Recorders are manufactured and distributed by Leupold, Voelpel & Co., of Portland, Ore. This company makes various kinds of continuous water stage recorders, as well as water stage indicators, all of which are operated by electricity. No attempt will be made in this brief discussion to describe these various instruments referred to; attention, however, is called to the fact that the selection of the instrument is not unlike the selection of other equipment, but depends on the local conditions and the results that are to be obtained.

Instrument Type G-7, selected in this case, is of the horizontal continuous recording type, which records each rise or fall of the river of five hundredths of a foot (.05 ft.). The drum or cylinder over which a sheet of cross-section paper travels is operated by an eight-day clock. In this way the record-sheet is forced to travel at the uniform rate of two and four-tenths inches (2.4 in.) every twenty-four hours, or one-tenth of an inch per hour. For each rise or fall of five hundredths of a foot of the river the recording pencil (or pen) is forced to move transversely on the paper a distance of one-fortieth of an inch (1/40 in.).

The cross-section paper is co-ordinated as follows: Vertical or transverse rulings are spaced one-tenth of an inch apart. Every twenty-fourth ruling is a heavy line. The longitudinal rulings are spaced the same as the transverse lines. Every tenth ruling is a heavy line. Transversely, one-tenth of an inch represents a change in level of two-tenths of a foot; five-tenths of an inch represents a change in level of one foot, or one inch represents a change of the stage of the river of two feet. The cross-section paper used on this instrument is ten inches wide. Other types of instruments are so constructed that they have different intervals both horizontally and transversely, and are used when conditions demand.

This instrument was installed under the direction of Professor L. E. Conrad, head of the civil engineering department of the Kansas State Agricultural College, by Mr. Geo. P. Grey and Mr. Harry Tyrrell, seniors in civil engineering of the 1917 class, as a thesis. These men worked for some time the later part of the second semester, constructing a stilling well, placing the "sender," placing the "receiver," and making the necessary connections until the instrument was in satisfactory operation. An existing telephone line, secured from the local telephone company by lease, serves to transmit the "messages" from the sender, at the river, to the receiver at the main engineering building, a distance of approximately two and one-half miles. This telephone line serves one purpose only, namely, to transmit the messages of the gage, continuous service was provided for through the local switchboard.

The instrument operates on the open circuit plan. Briefly the operation is as follows: A light perforated metal band, attached to the float, passes over the spine wheel of the sending mechanism, which is placed at the top of the shaft of the stilling well. This metal band is kept taut by means of a counterpoise which swings on the free end. As the float changes in level and at certain instances (the float having moved through the proper interval) contacts will be formed through mercury cups on the base of the sender. In this way a circuit is formed through the telephone line, the message going one way through the line for a rising river and in the opposite direction for a falling river. One of the wires, in this case, is grounded to complete the circuit. All messages are accordingly received at the recording station through the relay. The polarity of the relay will be neutralized or strengthened, depending on the direction of the current. Contacts are formed and the messages continue through the home circuit in the proper direction to cause one or the other of the solenoids to act, thus moving the pencil transversely on the cross-section paper, representing thereby a change equal to the gage interval. In this way, and with the forward uniform motion of the cross-section paper, a continuous record of the river is obtained. Fig. 3 shows the plan of wiring.

THE STILLING WELL

An ideal stilling well, presumably, would be a cement concrete shaft rigidly placed at a convenient point along the bank of the river arranged to maintain the true water level inside the shaft. The stilling well constructed and serving the purpose in this instance might be considered as only temporary. It consists of a 2 ft. x 3 ft. frame shaft some twenty feet high. This structure is located at the down-stream end of the east abutment of an abandoned Santa Fe Railroad bridge approach. This abandoned abutment stands at the water's edge at low water and is located north of the Golden Belt Highway bridge entering Manhattan from the southeast. This shaft is anchored to the masonry wall as rigidly as possible, fairly large cracks, however, are apparent between the shaft and masonry wall. During high winds small waves or eddies frequently rush around the edge of the abutment and dash through these cracks, causing the float to oscillate. These irregular vibrations of the float may cause the tape to get out of the guides and jump off of the spine wheel of the sending mechanism. This has occurred very seldom, however. Small leaves, papers and sticks find their way into the stilling well and collect around the float and these have to be removed occasionally. The float is, of course, subject to a "freeze-in" during the winter months. The instrument can be operated the entire year if the stilling well is of the best type, and if sufficient attention is given to correct difficulties at once. Kerosene, perhaps, if used around the float, will avoid freezing.

A direct reading river gage staff is placed on the outside of the stilling well shaft so that check readings may be made occasionally. These direct readings are reduced to mean sea-level by applying the proper elevation (992.89) to the zero of the gage.

THE SENDER

The sender is mounted on a horizontal base directly above the float at the top of the frame shaft. Attached to each end of the spine wheel shaft, near its bearings, are small ratchet wheels with their teeth opposed to each other. As the float moves up or down through the fixed contact interval, these ratchet wheels, turning with the spine wheel stem, operate small triggers or hammers which, when released, strike a small metal ball and force it to the opposite end of an inclined pivoted hollow tube. In this way the tube is forced to dip its points into a cup of mercury closing the circuit. This tube on forming the contact does not come to a horizontal position. In a short time the ball will roll back past center and the contact is broken. Fig. 1 shows wiring at the sender. Messages are intermittently transmitted through the line in one direction or the other, which are accordingly received at the recording station.

THE RECEIVER

The line is connected to a specially designed polarized relay which in turn is connected to the solenoids of the receiver through the station battery. When contacts are made the plunger of one or the other of the solenoids is pulled down and this movement operates the ratchet wheels. The ratchet wheels are mounted on the same shaft with their teeth in opposite directions. When the plunger arm is moved the pawl will turn the ratchet wheel the space of one tooth. This turns the spine wheel, which moves the pencil latterally a corresponding amount.

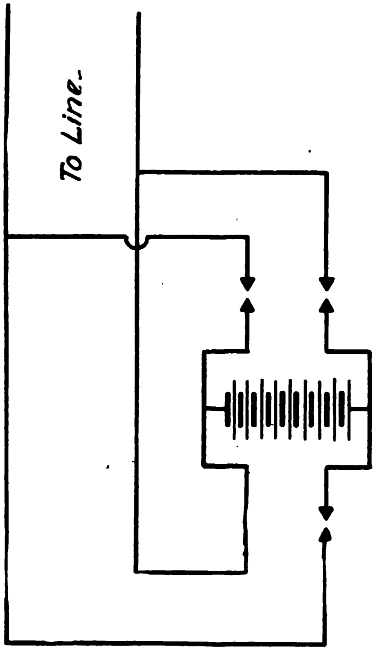


Fig. 1. The Sender.

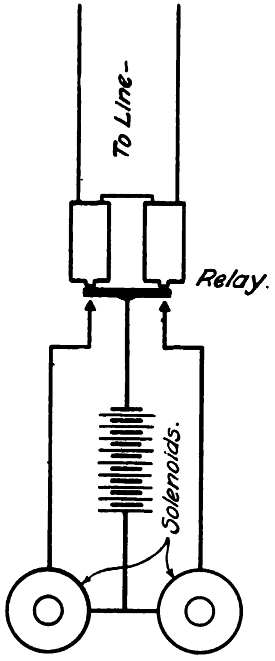


Fig. 2. The Receiver.

The two ratchet wheels of the receiver absolutely follow those of th esender, both in direction and amount. The receiver and the sender are both provided with suitable locking devices which prevent a contact being made except at the proper time. This arrangement protects the batteries, and prevents any movement of the pencil except that caused by the float. A one ampere fuse wire is used at the recording station to protect the batteries in case of continuous current.

A rising stage operates the right-hand solenoid and a falling stage the left-hand solenoid. This can always be obtained by reversing the line wires at the receiver end.

The record is kept by specially designed pens which do not blur or blot. Pencil points and holders are provided in case they are needed.

The records may be removed from the instrument at intervals of one month, quarterly or at any suitable period. Cross-section paper ten inches wide, graduated as aforesaid, will be sufficient to show all stages of the river at normal times. The instrument is set so that if the river drops a few feet below normal the pencil will not reach the lower margin of the sheet, in this case the lowest elevation being 990 feet. For a rising river the pencil will advance laterally on the sheet to the upper margin, this elevation being 1010. (The elevation of the Union Pacific Railroad bridge pier is 1008 feet.) If the river should go beyond the limits provided for on the paper, the pencil will at either margin reverse itself and continue to record a rise or fall, but move in the opposite direction. This reversal is made possible by the continuous band that runs over the spine wheels, which controls the movement of the carriage that supports the pencil. Suitable triggers will change the direction of the carriage at the limiting points. Fig. 2 is a diagram of the recorder wiring.

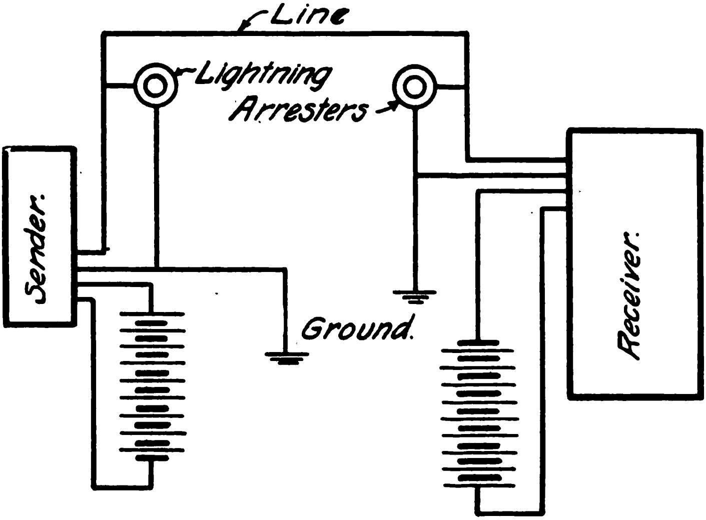


Fig. 3. The Wiring.

THE WIRING

Two wires may be used. One wire, however, can be used to advantage, the circuit being completed through the ground. The use of one wire greatly reduces the line resistance and results in the economy of wire and batteries. The line wires should be as free as possible from local telephone wires, thereby minimizing chances for continuous current through the line. Fig. 3 shows wiring complete.

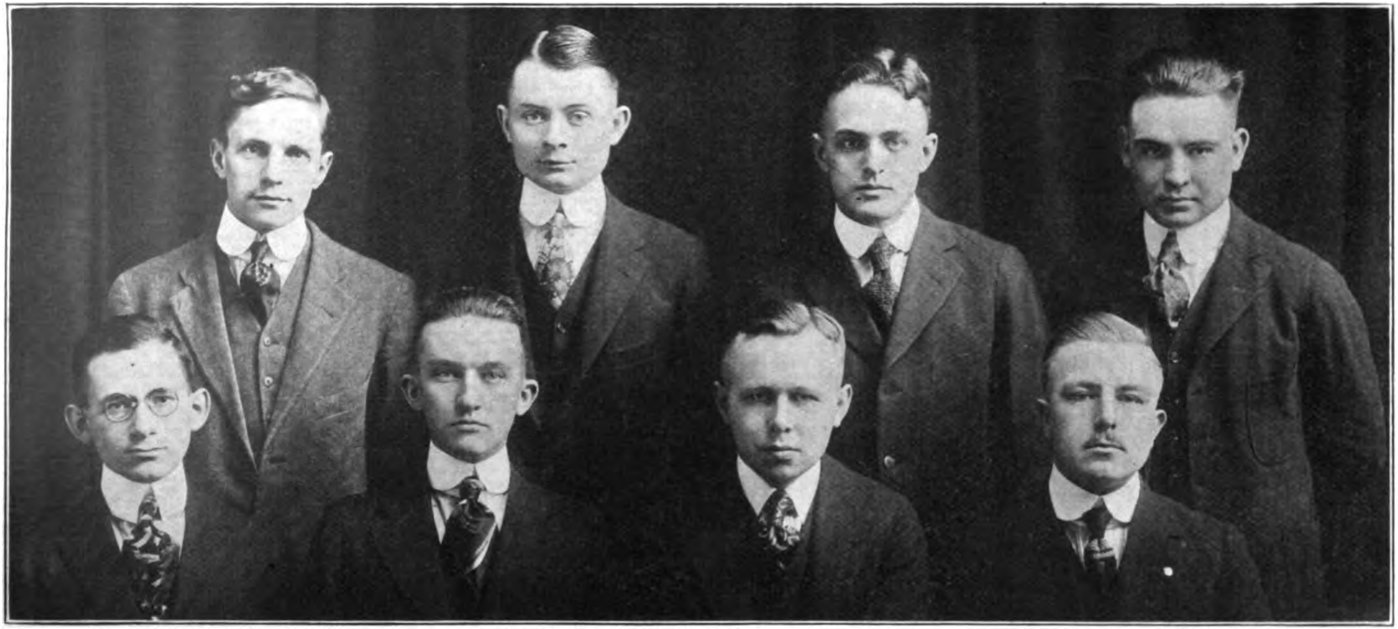
THE BATTERIES

Standard dry cells for open circuits (not ignitor cells) are the best. Columbia cells No. 6 give good results. The number of batteries required at the sender depend on the line resistance, from four to ten cells ordinarily being sufficient. Twelve volts (8 or 9 dry cells) are required to operate the solenoids of the recording mechanism.

Various features of this instrument are summarized as follows:

(1) Fluctuations of any liquid can be recorded as far as wires can be strung and messages transmitted;
(2) Only one wire is required for each unit;
(3) An existing telephone line can be utilized, and,
(4) Any number of recorders or indicators can be operated from the same source.

Apparently this instrument is past the experimental stage. There is little chance for lost motion between the float and pencil. Good results are being obtained and very little attention is required.



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The Purdue Engineering Review

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ENGINEERING EXPERIMENT STATION

The engineering Experiment Station at the university is an established fact and several lines of research are under way.

This includes, in the Electrical School, studies of electric cooking apparatus and an investigation of the fixation of atmospheric nitrogen.

In Mechanical Engineering, an experimental study of the measurement of variables entering into the carburetion of fuels in internal combustion motors. This involves a very careful control and measurement of the various elements of the problem. Preparations are being made for exhaustive tests of farm tractors under the joint direction of the Engineering and Agricultural Experiment Stations.

In the School of Civil Engineering, a study of the preparation and application of various road materials has been conducted.

Mr. H. W. Asire, Class of 1914, has been employed as General Research Assistant, with Mr. C. S. Kegerreis as Student Assistant.

A circular on Lightning Protection is now in press and material for at least two other bulletins is nearly ready for publication.

SCHOOL OF CHEMICAL ENGINEERING

This school now ranks third in size among the engineering schools.

A large number of the alumni are with the colors in various branches of the service; others are considered indispensable in industries contributing directly to the conduct of the war. The government, in creating a special Chemical Service Section, has taken official cognizance of the fact that the Chemical Engineer or the Chemist is of far greater value in his professional capacity than as a soldier, thus removing the undeserved stigma which might otherwise attach to such cases.

The present graduating class, from among the many positions offered, are practically all electing to enter those lines contributing directly to the conduct of the war.

Through the general revision of the schedule incident to the establishment of the Reserve Officers' Training Corps at this institution, it has been found possible to introduce a course in Physical Chemistry extending throughout the year; in doing so the requirement of a thesis is abandoned.

A register of Purdue graduates engaged in chemical lines has been in preparation for some time and will soon go to press. It is hoped that this will serve to keep alumni in closer touch with each other and with the institution.

SCHOOL OF MECHANICAL ENGINEERING

RESEARCH

Despite the fact that the personnel of this school has been greatly reduced in number due to the pressing needs of the war, those left to carry on the work have responded loyally. The result of the past year's work has been the carrying on of the twenty-eight lines of research and investigation. To do this $1800 worth of apparatus has been added to the school by way of equipment, and $4250 worth of loaned apparatus has been available.

Eleven companies have asked for and received aid in their research problems from the members of the teaching staff. Seven outside concerns have sent their apparatus to the Mechanical laboratories for testing. Fifteen articles have appeared during the past year in engineering magazines or publications of the various technical societies written by various members of the teaching staff.

SCHOOL FOR AUTO MECHANICS

The greatest work, however, has been the enrollment into government service of the teaching staff of the entire school, together with most of the laboratories. The undertaking of this work was brought about by the establishment of a Government School for Auto-Mechanics. Beginning April 29th and continuing for six months this school will turn out 1500 trained men for the army service. The lines to be taught will include auto driving, motor and chassis repairs, road repairs, and experimental laboratory demonstration.

The Government has established this school here because Purdue is especially well equipped for this class of service. Some changes were necessary and these have been quickly made. The west wing of the Steam Laboratory has been completely dismantled of all equipment to make room for eighteen chasses to be used for general repair work. Likewise the equipment has been removed from the Hydraulic Laboratory, which will be used as a motor repair shop.

All necessary supplies and equipment have been obtained, including 18 motors and 18 chassis for repair work, also 20 pleasure cars for road demonstration and roadside repairs and 25 Government trucks of five different makes. The instruction will be done by forty-eight instructors and assistants. Part of these men come from automobile factories and garages, but a majority come from the Senior class in mechanical engineering. This has all meant a great deal of added duties to those directing it, but the anticipated excellent results have continually been an incentive, so that all have worked cheerfully and harmoniously toward the fulfillment of a most splendid way of serving our country.

LEFT FOR SERVICE

Mr. C. B. Veal, Professor of Machine Design, is now a Major, and is stationed at the Curtis Aeroplane plant in Buffalo as Chief of Inspectors.

Mr. L. W. Wallace, Professor of Railway and Industrial Management, is assistant general manager of the Diamond Chain and Manufacturing Company, of Indianapolis.

Mr. T. T. Eyre, Assistant Professor of Mechanical Engineering, is a Captain in the Engineers' Corps.

Mr. H. B. Ensign, Instructor in Machine Design, is a Second Lieutenant in the Ordnance Department.

Mr. J. A. Sauers, Instructor in Machine Design, is in Government Service.

Mr. F. A. Hill, Instructor in Mechanical Laboratory, is designing pumps for the Government.

INCREASE IN TITLE

Mr. G. C. King has been made Assistant Professor of Engineering Design.

Mr. R. W. Noland has been made Instructor in Heating and Ventilating.

SCHOOL OF ELECTRICAL ENGINEERING

NEW EQUIPMENT

A contract was placed during the year with the Westinghouse Electric and Manufacturing Company for the new high voltage laboratory equipment mentioned in the last number of the Review. This consists of two 300,000 volt, 135 k.v.a. transformers each with one terminal grounded. These can be used in series for furnishing 600,000 volts with grounded neutral. The transformers will be operated from a 2200 volt primary supply. An ingeniously arranged step-by-step control system has been devised for obtaining a gradual increase in voltage by steps of less than 1%.

Although delivery on this apparatus is rather uncertain because of war conditions, the Electrical Building will be enlarged during the coming summer for the reception of this apparatus, and it is hoped that the latter may be installed in the early fall. Purdue University will then be equipped with the most complete high voltage testing laboratory in the Middle West.

RESEARCH

Although greatly handicapped by limited high voltage supply, investigations of electrical methods for the fixation of atmospheric nitrogen have been continued the past year. The preliminary experiments have proven of sufficient merit to warrant the construction of a larger and more complete plant with which to investigate this new process. It is expected that this equipment will be complete and tested within another month. These investigations in the School of Electrical Engineering are being carried on under the auspices of the Purdue Engineering Experiment Station.

Exhaustive tests have been carried out during the past year as a part of the Engineering Experiment Station work, upon a large number of modern designs of electric ranges. These have been very kindly furnished by the manufacturers. Not only scientific research investigations have been made, but also practical cooking tests have been carried on with the co-operation of the Department of Home Economics. It is expected that a bulletin will be published in the near future covering these tests.

One of the difficult problems in connection with the supply of electrical energy from large central stations to industrial plants, which have suddenly increased their demands greatly because of war contracts, has been the maintenance of service over high voltage distribution systems. The secret of success for such a system is the reverse energy relay. Some important research work in connection with relays of this type is being carried on at present in the electrical laboratories with the hope of improving this particular type of service.

SPECIAL SIGNAL COURSES

Upon request of the Signal Corps, U. S. Army, Seniors in electrical engineering have been offered rather an extensive course in Radio Signal Engineering in place of an equivalent amount of required work during the second semester. Practically all the Seniors are taking this specialized work with a view toward entering this service after graduation. Notes upon recent developments in signaling at the front are supplied by the Signal Corps for confidential use in the instruction of these courses.

In addition to this regular work, three different classes in sending and receiving the continental code used in Radio Signal Engineering, at the front, have been in operation since last December. Large numbers of the students are taking this training on outisde time, as the Government requires a proficiency of twenty words per minute in this code.

PERSONNEL

Professor L. D. Rowell left last spring for the First Officers' Training Corps and after three months' training was commissioned as Captain and stationed at Washington as Recorder of the Engineering Troops. He is engaged in a large amount of development work along engineering lines in connection with the purchase of equipment for the expeditionary troops in France.

Messrs. J. B. Sheadel and H. E. Phelps have re-entered active engineering work during the year, the former with the Indiana Union Traction Company and the latter with the American Telephone and Telegraph Company of New York.

Mr. Emerson Pugh, a graduate of the School of Electrical Engineering, has been secured from the General Electrical Company at Schenectady as an assistant.

SCHOOL OF CIVIL ENGINEERING

RESEARCH

In the Hydraulic Laboratory the experiments have been completed on the resistance offered by various forms of valves and spiral riveted pipe, and the efficiency of spraying nozzles. The data have been prepared for publication and will appear as a bulletin of the Engineering Experiment Station.

A new line of research is the calibration of a one-inch circular orifice under heads ranging from 100 to 250 feet.

The Laboratory for Testing Materials has completed the following researches:

A series of impact tension tests of steel have been made for the U. S. Navy Department.

A study of the effect of hydrated lime upon the strength and density of concrete has been made.

There have been constructed and tested, three full sized reinforced concrete floors supported on columns, representing four sixteen-foot panels of the so-called flat slab type. These constructions have been loaded with brick up to six hundred pounds per square foot and the deformations in the various parts of the floor measured with extensometers. These are the most extensive flat slab tests that have yet been made, and the results have important applications in the design of warehouses and like structures.

The investigations of the kinds and sizes of sands, gravels, and broken stone for the purpose of road building have been continued. A machine for testing concrete under the forces arising from abrasion has been constructed, and the use of this new form of test will be investigated during the coming year in conjunction with the co-operative survey of road materials, that the laboratory is to make in conjunction with the State Highway Commission.

The Laboratory has been of continued service to the state, particularly in testing the paving brick supplied for the construction of brick roads throughout the state, both for the county officials and the State Highway Engineer. The Laboratory is also the official Laboratory for the tests of steel from several plants engaged in the manufacture of munitions and other war materials. An important series of tests has been made upon the species of tropical pine sent from the state of Nicaragua.

The hopes for securing a million pound testing machine for the Laboratory have not been realized on account of the state of industry brought about by war conditions.

A series of measurements were made upon the trusses of the new Armory to determine the stresses brought about by the weight of the trusses and the roofing. These measurements showed that the calculations of the design agreed with the stresses.

HIGHWAY DEPARTMENT

Professor George E. Martin received a commission as Captain in the Engineers' Corps of the U. S. Army and Dean R. C. Yeoman, graduate of the School of Civil Engineering of the year 1907, was appointed to succeed Professor Martin.

The Fourth Annual Road School was held in January, 1918, and was well attended by the road officials of the state. In February and March a series of so-called road schools and conferences were held by the Highway Department with the assistance of the State Highway Commission.

Professor Yeoman was elected Assistant Secreatry of the County Highway Superintendents' Association.

SURVEYING CAMP

Surveying camp was omitted the summer of 1917, but will be resumed in 1918 with the attendance of both Juniors and Sophomores.

GENERAL

From the Faculty of the School of Civil Engineering
Professor Albert Smith is Major in the 309th Engi-
the following have entered military service:
neers.

Professor W. A. Knapp becomes Captain in the 7th Regiment of the U. S. Engineers.

Professor G. E. Martin is Captain in the 23rd Engineers.

Mr. W. S. Stanley is 1st Lieutenant, E. O. R. C.

Mr. M. J. Stinchfield, Jr., is Corporal in U. S. Marine Corps.

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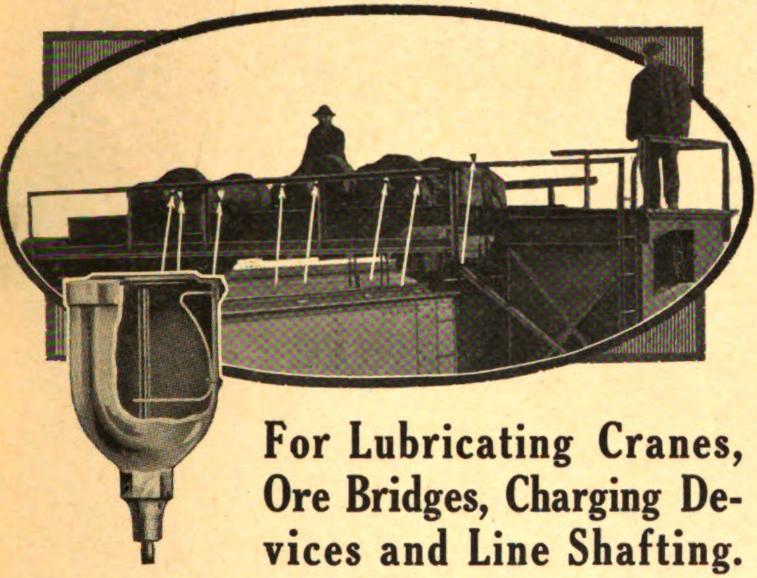

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THE PURDUE ENGINEERING REVIEW

No. 15 PURDUE UNIVERSITY 1919-1620

AERONAUTICS

By Lt. Geo. W. Haskins, '17

Of silver wings he took a shining pair,
Fringed with gold, unwearied, nimble swift;
With these he parts the winds, the clouds, the air,—
And over seas and earth himself doth lift.
Thus clad he cuts the spheres and circles fair,
And the pure skies with sacred feathers clift;
On Lebanon first his feet he set
And shook his wings with rosy may-dews wet.
—Tasso, Canto I, XIV.

How beautiful! Ever since the cave-man days when man was obliged to chase his food or be chased by it, he has admired the aerial evolutions of wing-gifted creatures and aspired to imitate them. An old question—once dear to philosopher and fool like, and for a long time it has been the affair of untechnical inventors. Man has racked his brain and bruised his body in futile attempts to "mix with the clouds" or "as smoke arise."

From the early day when man was seen climbing to the top of precipices, trees and what not and projecting himself from these heights into space, with nothing but a modified kite, parachute or contrivance with which to defy gravity and resulting in regrets and bad bruises. And a detailed chronology from the earliest accounts of Daedalus and his Son's escape from prison by means of wings, or of a learned Jesuit who represented the anger of God by putting into a strong wind, a flying dragon loaded with a mixture of sulphur, pitch and wax, which was ignited and eventually vanished, would be most interesting but is not to be repeated in this paper.

It is the aim of this paper to give a brief resume leading up to present aircraft, as well as some of its past and present problems and possibilities.

A bird was not found large enough which could be tamed and bridled and used for a man to ride, but the enterprising and gifted engineers did construct certain surfaces resembling in varying degrees, the wings of birds or certain flying quadrupeds, with which it was possible to glide with a degree of success from a higher to a lower level. This marks the beginning of the use and experimentation of gliders, the growth of which developed into our present *"airplane."* For a long time, the gliding of vultures, of gulls and of certain fishes, could be imitated with profit, but when they esayed power flight, they invariably and egregiously failed. It may be physically possible for a very powerful athlete, putting forth herculean energy for a few seconds, to sustain himself on wings of enormous spread; but in every lightest zephyr he would be as helpless as a thistle seed.

Our own famous Wright Brothers, as well as Langley, Chanute, Berliot and others, began their early experimentation upon gliders, gradually modifying the construction to include power units of varied character.

On account of experiments upon monoplane (one wing) and multiplane construction, as well as types such as Langley's in which wing surfaces were in the same plane, but some were ahead of others, is not for this volume.

It is interesting to know, however, that the first authentic successful power flight is credited to the Wright Brothers, in the year 1902, when one of them flew a hundred feet at a height of about 5 feet, and with the other brother running alongside. In the brief period since that date, and especially during the war, aviation has had a most phenominal growth until now crtain craft will develop a speed of 2½ miles per minute, climb to the dizzy height of about 7 miles, carry several tons of extra weight and open fields of remarkable endeavor.

As the derivation of the word indicates, "aviation" is employed to refer sofely to the flying machine, or the heavier-than-air type, while under the general terms "aeronautics", similar apparatus which depends upon lighter-than-air gas to give the necessary lightening power.

The following are the two general classifications of aircraft:

A—Lighter than Air.
B—Heavier than Air.

The lighter-than-air craft have a function to perform which is out of the scope of work of the airplane, and should be considered under the general topic Aeronautics. Many early inventions are credited to China, and it is reported that a balloon was made to rise by them in the fourteenth century, in celebration of the ascension to the throne of a certain king.

All attempts at human flight have gone to show four possible ways for man to navigate the air: (1) He may imitate the flight of birds with flapping wings; (2) He may use the vertical screws or helices to pull him up; (3) He may sail like the agle in an airplane, and lastly (4) he may raise himself by means of gas bags and drift with the wind or move forward by means of propellers.

The balloon like airship has been more highly developed than any other type of aerial craft, probably because it offers the most obvious means of overcoming the force of gravitation and depends upon Archimedes' principle:—Every body which is immersed in a fluid is acted upon by an upward force, exactly equal to the fluid displaced by the immersed body. Thus, if the total weight of a balloon is less than the weight of all the air it displaces, it will rise in the air. It is desirable, therefore, to obtain for use, a gas with as low a specific gravity as possible. Since hydrogen has a weight of about .005 pounds per cu. ft., and the weight of air is .08 per cu. ft., thus one cu. ft. of hydrogen will be acted upon by .075 pound, or the difference, tending to push it up.

How fortuitous the primal steps of science! Joseph Montgolfied, the inventor of the lamp chimney and hydraulic press, during the siege of Gibralter, is supposed to have conceived by the puff of a petticoat, the idea of aerostation by means of smoke! He gave a public inauguration of aeronautics at Annonce, on June 5, 1783. The mass of his frame weighed 300 pounds and rose to a height of 6000 ft. and sank gently to the ground. The passengers were a sheep, a rooster and a duck and were none the worse for their strange experience except that the sheep had trampled the rooster and lamed him.

Later developments saw many changes in design and capacity and some are reported to have soared to 29,000 ft. for observations. Now it is reported that transportation is possible daily between Berlin and Switzerland in dirigible Pullman accommodations for many people and in which meals are served! Could anything be more delightful than to be breakfasting as you floated over beautiful scenes of ruined castles, of little country hamlets tucked away in the ravines, of church spires revealing the touch of a master chisel, of immersed fields once again laden with grain and woods so dense that light never reaches the interior? What will the new one million cubic foot dirigible have to offer?

For those who are interested, mention will be made of some of the problems of mechanical flight which comes more directly within the purview of the aeronautical constructor. It should first be understood that the airplane is primarily a developed glider so designed to make it capable of lifting itself on lifting surfaces called wings or aerfoils.

A vertical component of wind pressure against these wings executes the lift and raises the plane together with its load.

We are so accustomed today to consider aerial flight as an essentially rapid mode of locomotion, that it is necessary to emphasize the fact that speed is obtained, not as might readily be supposed by *virtue* of any show of economy —as is true of a railroad train—but *in spite of* a co-efficient of resistance and at an expenditure of power of an extravagant character. In speaking of the limiting dimensions or capacities to which an airplane can hope to attain, Handley-Page mentions that one machine having only twice the linear dimensions of another machine will require approximately eight times the power.

The "*head resistance*" is the sum total of all resistances encountered in flight. Resistance from struts, wires, edy-making and skin-friction resistances, due to the body, landing chassis and spars, whether belonging to the body or the aerfoil, vary with the squares of the velocity (approx.) The direct outgrowth of all has been the study of *Streamline Flow*. The study of fluid and rigid dynamics as well as stability and control are of vital import to aeronautical engineers, but these are primarily matters for the Physicist and Mathematician. The Engineer can well afford to leave questions of this kind in the hands of a Specialist.

Propulsion.—From experience and theory, it seems there is only one method of propulsion available, namely—screw-propeller. The laws of dynamic similarity between aeronautical and submarine propellers are, with reservations, strictly applicable, and conditions of usage in water and air may be compared by noting the relative densities of the two media approximately 800 to 1.

Motive Power Installation.—As a prime mover, the internal combustion engine holds the field. The petrol motor has eliminated all competitors either on the score of weight per horsepower or weight of fuel. For gas engine engineers this phase of aeronautics has shown a most spectacular growth, and the problems immediately before him offer an equally attractive field. Not enough is known of engine performance under rare air or at high altitudes, how to preserve maximum power, eliminate preignition, and the relative merits of various types at these high altitudes.

Control.—The controlling mechanism is unique and important but it will only be observed here that an airplane has control about three axes perpendicular to each other, namely: longitudinal fore and aft (transverse) and vertical. Control is closely related to stability, thus three kinds of stability are of very great import to the aeronautical engineer. Without any one of longitudinal, lateral or directional stability, flying can be very hazardous and in addition to these, may be mentioned spiral or rotative stability. As mentioned above, this should be left to the specialist, but the question is not obscure and more knowledge on the subject is available than can be utilized.

Landing Chassis.—A word about the alighting mechanism should have a place here. The number of types are two—according to whether the machine is designed for land or marine usage. The function is to raise the machine a proper height above the ground or water so as to give clearance for the aerfoils, propeller, etc. Rubber has been universally used to absorb the shock in landing, but there may be possibilities in other methods. The landing mechanism *should* be complete in itself for safety and attempts are being made to construct a mechanism which will be possible of folding or condensing, to cut down the power loss in transit for which it is responsible.

Another phase of the growing Air Service has evolved its own and peculiar ills. Coasting down a snow capped hillside by savages upon a slab of bark, or more recently, upon toboggans, had its hazards, which in turn required a particular treatment or attention. Railroading in modern operations does not, among other things, tolerate color-blindness in its operators. Electrical engineering was ushered in with no small amount of shocks and burns. With water navigation came seasickness, and now, air navigation calls upon the Medical Profession for cures and treatments for heart dilation, oxygen wants, special nerve strain and air sickness.

It was because of these exceptional or unusual demands upon the human body that a special examination was prepared with a view to picking men best able to stand up under the great variety and intensity of stress and strain, as great as that in the airplane. It is not that a flier must be a "superman," nor can one man properly fill all the diversified classes of work such as pursuit, reconnaisance, photography, bomb-dropping and night flying, regardless of whether he is physically fit and properly trained. Aviation is not merely spectacular, man was not originally intended to be a flier, to spend much of his time at high altitudes where he cannot get the proper amount of oxygen and the problems of the present war in the air lacked the accumulated experience of previous wars to indicate their solution. The air fighting force had and has its potentialities of disaster, contested them, according to the best experience available, and is still doing a great work in correcting the ills as they have been revealed.

In closing, it is desired to emphasize the vigor and extent to which commercial aviation has already been pushed, but even yet, the public, to a great extent, treat the whole affair as a dream of the future. Commercial Aviation is its own reward and is a direct asset in time of war emergency, as the planes can be quickly converted. It needs guidance and encouragement.

Already a route is nearly completed from Cairo to the Cape. There is talk of an expedition to the South Pole; there are transcontinental routes over many parts of Europe and good Air Service between Paris and London has been a fact for some time. South American countries have already looked upon Aviation as a solution in opening obscure mining and other rich lands.

Where a certain party of prospectors spent two months trying to arrive at a new, rich mining district and were eventually destroyed, an airplane would have made the trip in a little over two hours.

America is by no means dead, but has organized several companies.

It is hoped that the foregoing has given the young engineers something to think about. The field is large, fortunes will be made and only the surface has been touched in this new and promising industry.

THE ENGINEER AND THE COMMUNITY

E. H. Sniffin

Manager of the Power Dept., Westinghouse Elec. & Mfg. Co.

It is useful sometimes to stand off a little way and take a view of your work, the field of your activity and its relation to the general scheme of things. To go up on a mountain, so to speak, and look down upon the world, to ponder what its inhabitants are all doing and why, and where you fit into the plan. One may well muse ove rthe purpose of it all. It seems like a very fair earth, where men ought to be very decent and very comfortable. Then why have they made such a sorry mess of it? Perhaps it is in the divine scheme that they should make a mess of it. We know there has always been a terrible struggle, perhaps always will be, for the things that bring us food, covering, shelter and delight for the senses, and the landscape will soften very gradually as men slowly learn that it is not a struggle of units, but a struggle of humanity in the mass; that we cannot live alone, but that we depend upon each other and that the one substantial happiness that comes to any man is to be measured by the extent of his service to others.

And so I cannot talk about the engineer until I find his place in this scheme of things; and when I see what he has done for the world, when I find that within the last century he has practically revolutionized the living conditions of civilized people, and made the world more habitable than was even dreamed of by the greatest imaginations of former ages, I am bound to conclude that the engineer, perhaps above all others, has contributed most to the material welfare of humanity. What is known as the world's industrial revolution began about a hundred years ago when by the application of steam as motive power and the inventions of machines for various purposes which it stimulated, and the onward march of scientific discovery, there followed the age which has culminated in our own day in a world transformation. And what a romance it has been, this work of the engineer. Not alone for money gain has he labored, albeit he has made it for others, but to him has come a wealth greater—

> "Than all Bocara's vaunted gold,
> Than all the gems of Samarcand."

the consciousness of a great world service. He has hitched his wagon to a star. Do you remember that beautiful poem of Kipling's which begins—

> "When earth's last picture is painted,
> And the tubes are twisted and dried."

and then he describes that heavenly existence where—

"No one shall work for money,
And no one shall work for fame,
But each for the joy of the working,
And each in his separate star,
Shall draw the thing as he sees it,
For the God of Things as they are."

The engineer does not have to die to do that. He does it while he is here. He has been the interpreter of physical facts and natural laws and mashalled them into useful paths of world employment. He has "drawn the thing as he sees it, for the oGd of things as they are." I sometimes imagine when I look at a great piece of engineering work—an ocean steamer, a long span of bridge, a big dam, an immense power house,—that if the creator of it should have passed into the shadows, his soul must still hover near this monument of its earthly expression, for that would be Heaven indeed.

It is this feeling that I have for the engineer, the love and esteem I hold for him, that prompts me to ask this question—Why is not the engineer a more conspicuous member of the community? The query is by no means original with me. It is beginning to concern the engineer himself. It has been accentuated herhaps by his large contributions to our victory in the great war, not only through his engineering achievements, but his power of organization and administration, the employment of a mind trained to deal with facts and form accurate conclusions. It has been the frequent topic before many of our engineering socities.

The problem, it seems to me, lies more particularly with the engineer as an individual and that is the chief thought in my mind. Why is he not a more conspicuous citizen? Why do we not have more of the benefit of his trained mind in our public affairs? Is he to be so highly specialized in his profession as not to be a man among men, he of the trained mind, and not help to solve the problems common to us all? Shall we leave it to the lawyers to hold public offices? If so, I am wondering what special qualifications the lawyer has for the public service that the engineer does not possess, or at least might not readily acquire. I can very easily imagine that the engineer in his lifetime search for facts, for the truth of things, dealing as he must with the economic problems which suffer no gloss or guile, might indeed be a very valuable public servant. I am told that the membership of the Sixty-Fifth Congress contains not a single engineer in either the Upper or Lower House. It must be a matter of chagrin to us, when we come to think of it, that in our country with its wonderful scientific and mechanical achievements which have been the biggest thing in our development there stand out very few among our engineers or scientists whose voice is heard in our National councils. What a pity; and how much better it would be for the country if the reverse were true.

I think the trouble starts at the school. I am glad to say that that feature is improving, but I think rather slowly. As a rule technical school graduates have shown too much the effect of a specialized training at the expense of an education. The engineer seems to be stamped upon them at the expense of the men. Their general interest in things has not been stimulated. They have not the catholicity of taste or ready response to environment that marks the well rounded man. Then followed their years of work, their concentration upon the thing they loved, with little heed for the varieties or amonities of our common social existence. I do not complain of the engineer's usefulness. There is nothing but praise to be said for the value of his work. But he lives in a world of men who have their own way of appraising his value and I am contending that he has the training that will enable him to serve them in a greater degree still, if he will come out of his hermitage and mingle with the open world. We must remember that in our own country there is very little spontaneity of recognition of the men of science. In the older countries they are selected for distinguished honors. Great Britain knights her Thompsons, her Parsons, her Whitworths, her Bessemers, a long list of them who take place with her statesmen, her scholars, her publicists. Poincare, the President of France, is said to be one of the world's greatest mathematicians. Clemenceau was once a physician and I am told that there are about seventy physicians in the present Chamber of Deputies. And Paderewski is now running Poland. If this artist, who I suppose is temperamental, can leave his keyboard and work with all his brain and brawn and heart and soul for the nationality of his country, what do you suppose the engineer might do? Artist that he is, he fits very well into my theme. Our first President was an engineer. Franklin was a scientist. But both of these great men had other compelling interests that made their names immortal. The habit went out of fashion at an early date.

The fact is that our own country is not inclined to exalt a man into realms of distinction beyond his definite accomplishment, although it does quickly recognize him for what he does, and it is as true of human nature here as elsewhere, that your light gives better illumination when exposed than when hid under a bushel. Our friend, the engineer is too modest. Any man would be who spends his life struggling with natural laws; he finds out how small he is. And I suppose it to be natural that he should view with but casual interest the many phases of our social life, and especially the banalities, as he sees it, of politics. So he keeps aloof from all these trifling, artificial, unsubstantial affairs, and remains the engineer. And the public lets him have his way. Now that is undoubtedly very wrong. There is nothing more true than the fact that people live upon the earth in a social state of interdependence, the most successful of them under representative forms of Government. Through these representatives national, state and municipal laws and local ordinances are enacted, supposed to give the maximum benefit to the greatest number. These important functions are exercised often from political motives purely. Very often the motive is honest and sincere, but the result is unwise, unsound and sometimes vicious in its consequences. Do you suppose, for instance, that the hydro-electric situation in our country today would have existed had there been among our law makers enough men with the engineering and economic knowledge to know what they were doing? No, it required a world war, with its stress upon every ounce of our national energy to make us fully realize that we have about twice as much undeveloped water power in this country as there is steam power in use, including locomotives, scarcely any of which will invite a dollar of capital under our present ill-considered laws. So the President is now trying to speed up the remedial legislation that has been under consideration for many years.

But, as I said before, the engineer will not be picked from his profession to serve in public life. He must himself show social and public activity. He must make men aware of him. I wonder if I might say he must advertise himself —that word "advertise" has a new significance to me since I have seen how necessary and successful it was in such a good and worthy cause as our Liberty Bond campaign. When Emerson said that if you could do something better than any one else could do it, the world would make a path to your door, even though you lived in the heart of a wood, he had in mind only one phase of human nature. It is equally a fact that the greatest truth that was ever established will be accepted more readily if it hits you in the face at every turn. Not as an engineer shall he advertise, but as a man of superior mind, who in the sweep of his knowledge and the sincerity of his purpose shall become a strong and helpful influence in our public affairs. We are living in a critical period of the world's history. We have just expended nearly ten million lives and two hundred billions of wealth, and were ready to give all our lives and all our wealth to preserve our heritage of freedom and righteousness. Thrones have been demolished and Governments upset and the world is trying to find its way, let us hope, to a new and better order of existence. Meanwhile, there are tens of millions of people living under conditions of social chaos, and it would be a bold man who could say how far it will go. or indeed, whether our own fair land shall be immune from the blight of these poisonous theories that have already spread from the Volga to the Rhine. Let us hope not. But let us make sure that it shall be every man's duty to come out of his isolation into his fullest obligations of citizenship; that men of trained mind and trained character shall seek their places in the councils of our country; and that the engineer above all others shall no longer exclude himself from the fullest measure of public service.

PURDUE ENGINEERING SCHOOLS IN WAR TIME ACTIVITIES

By Prof. G. A. Young, '97

The statement is ofttimes heard, "that it is easier to change from the ways of peace to the perilous times of war than it is to change from ways of war to the perilous times of peace." Whatever truth there may be in the above, it is a fact that the engineering schools turned their energies to the training of soldiers with amazing ease and recognized efficiency. Purdue was one of the first educational institutions to offer her facilities in any way possible to aid the Government in the training of soldiers, with result that April 25, 1918, found the new Armory filled with 800 men sent here for instruction in auto mechanics. This number was increased until at the maximum, the engineering schools were training 100 men in concrete work, (Civil) 300 in radio, telephone and signal work, (Electrical) 800 in auto mechanics (Mechanical) and 400 in truck masters (Mechanical). The work involved thousands of dollars of extra equipment and nearly a hundred extra instructors. The fine equipment, the high quality of instruction could not but get results in finely trained men. After the eight weeks of instruction one group was sent on and another took their places. That the Purdue trained soldier in the war time courses had received specially fine training was evidenced sending group after group of men here from other insti- by the fact that the Government Board made special mention of the work here in their monthly reports and by their sending group after group of men from other institutions to study the Purdue methods.

It is interesting and very significant, that there are now enrolled in the regular engineering courses many students, who had been sent here by the Government in those trying war time conditions, recognized even then the value of engineering as given at Purdue University and after demobilization, hastened back to Purdue to fit themselves for the engineering profession.

ENGINEERS IN THE ARMY MEDICAL DEPARTMENT

By A. G. Husted, '12

Prior to the entry of the United States in the World War, commissions in the medical department of the U. S. Army were so jealously guarded that aside from the veterinary and dental corps (officers of which were graduate veterinary and dental surgeons) no commissions were granted to any but graduates of recognized colleges of medicine. However, as soon as it was recognized what an enormous army this country would have to furnish to be of any material assistance in the war, it was seen that certain other specialized professions could be of a great deal of assistance to the medical department.

The inclusion in the medical department of non-medical officers was prompted by two considerations. In the first place, it was seen that in order to supply the proposed army with a sufficient number of medical officers if all were graduate physicians the country would be depleted of its physicians to such an extent as to be dangerous to the health of the nation, and besides, there was some doubt as to whether a sufficient number of doctors could be induced to volunteer their services. In the second place, there were some duties connected with the medical department that could be more satisfactorily performed by other professions.

In view of the foregoing considerations the sanitary corps was formed as a temporary branch of the medical department. Whereas all other commissioned branches of the medical department were limited to their particular branch of medicine, the sanitary corps had no well defined limitations. It was quite natural, therefore, to expect to find various professions represented therein. The principal divisions finally included were administrative, phychological, nutrition, and engineering.

Since this paper has to do with the engineering division only, the administrative, phychological, and nutrition divisions will be passed over.

Officers of the engineering division were drawn principally from sanitary engineers and sanitary chemists in the various branches of their profession such as engineers and chemists connected with municipal and state health departments and the United States Public Health Service, consulting engineers and assistants in water purification, sewerage disposal, garbage disposal, etc., and other similar or allied branches of the profession.

The principal positions to which these officers were assigned in camp organizations were assistants to camp sanitary inspectors, commanding officers of sanitary corps detachments, and camp sanitary engineers. Overseas they were in command of sanitary squads and on staff duty looking after water supply. As the writer did not reach France very little definite information can be given concerning the work of the sanitary corps there. Consequently this paper will be confined principally to work in this country.

As assistants to camp sanitary inspectors, sanitary corps officers were able to fulfill the first consideration prompting the creation of the corps. That is, they were able to do work which otherwise would have been done by medical corps officers, and in this way released doctors for work which required medical training. The duties of these assistants to camp sanitary inspectors consisted principally in making sanitary inspections of regimental and other camp areas, and also of rubbish dumps, manure dumps, garbage collection and disposal, etc. In a few cases sanitary corps officers were assigned to duty as camp sanitary inspectors, but since the work of the sanitary inspector included the control of communicable diseases as well as general sanitation, this officer should be an epidemiologist as well as a sanitarian. Consequently the sanitary inspectors were usually medical corps officers. Sanitary corps officers acting as assistants to sanitary inspectors were able to do very little independent responsible work, but occasionally were able to render a great deal of assistance, especially in matters requiring engineering knowledge and training such as water supply, drainage, etc.

Commanding officers of sanitary corps detachments were almost without exception sanitary corps officers. None of the duties pertaining thereto required medical skill, and thus doctors were released for medical work. Furthermore engineering training was advantageous, since the work of these detachments consisted largly of constructing and policing drains.

As camp sanitary engineers, sanitary corps officers were able to do their most important work as engineers as far as work in this country was concerned. At least this was the case where the camp sanitary inspector did not try to assume all authority over the engineer's work as well as his own. The writer has found in his experience that this sometimes happened. Before the creation of the sanitary corps sanitary inspectors (who were of course medical corps officers) had complete charge of all sanitary inspections including inspection of water supply, sewage disposal, drainage, etc., as well as the control of communicable diseases and the general health of the command. After the creation of the sanitary corps, however, and the inclusion therein of sanitary engineers, the position of camp sanitary engineer was created. For a considerable time after the creation of this position no definite instructions were issued defining their duties. Consequently, camp sanitary inspectors continued to assume control of work that was intended to be taken care of by the camp sanitary engineers. Nor could they be blamed. Finally, however, instructions were issued by the war department clearly defining their status. By these instructions the camp sanitary engineer was made a direct assistant to the camp surgeon on such matters as general sanitation, mosquito control and drainage, water supply, sewage disposal, garbage disposal, etc. It became his duty to inform the quartermaster officer in charge of utilities of faulty or poor operation of water supply, sewage disposal plant, or any other utility affecting the general health of the command. He was also required to render a monthly report to the surgeon general outlining conditions at his camp with reference to the above mentioned matters. It will be noted that as camp sanitary engineers, sanitary corps officers were able not only to fulfill the first consideration of being able to take the place of medical corps officers and release them for medical work, but were able actually to render special assistance to the medical department by virtue of their special training along the line of sanitary engineering.

Looking backward over one year of service in the medical department there is no doubt in the mind of the writer as to the wisdom of establishing the sanitary engineering division of the sanitary corps. The writer served as assistant to camp sanitary inspector, camp sanitary engineer, and commanding officer of a sanitary corps detachment. While the work was far from being all technical there is no question but more efficient work could be done in these positions by engineers than by doctors.

It is to be regretted that provision has not been made in the army reorganization bill for a permanent sanitary corps in the medical department. While the need for such a corps and especially the engineering division is not nearly so great during peace time as in war, yet a nucleus organization would greatly facilitate matters should another war necessitate putting a similar army in the field again.

WITH THE AIR SERVICE OF THE UNITED STATES ARMY

W. O. Erwin, '20

In order to be able to appreciate what the United States Government was confronted with in the development of the Air Service during the late war, it will be necessary to relate a few fundamental facts.

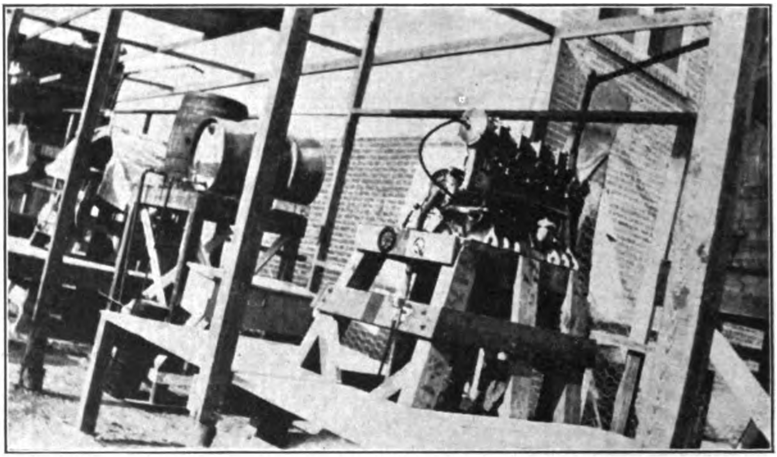
First, wholly unexpected problems arose on all sides, for matters were being dealt with which were entirely new to everyone concerned. Knowledge had to be acquired by bitter experiences and disappointments, the best hopes often meeting with sharp disillusions, and fears hardly being expressed until they became realities. The whole problem of the air force with which the United States was confronted at the beginning of the war was approached, therefore, without a realization of the many pit-falls.

Much time was spent in forming a Bill to be introduced to Congress for appropriations, etc., but there had to be a beginning and, although many mistakes were made and criticism came from many sides, and, too, many doubts were in the minds of our leaders, still the whole program followed through from the beginning of hostilities in 1917 until the end in 1918 was a romance, whether it be called a success or a failure, and will bear comparison with any branch in this great war.

At the beginning of the war the United States Air Force consisted of only eighty-five students, fourteen civilians, and no reserve military aviator instructors were available as a teaching force. The equipment at the fields consisted of five primary training planes, nine motor trucks, eight motorcycles and three automobiles. The whole aviation consisted of sixty-five officers and 1,120 men. This represented the ground work on which it was necessary to erect the development called for. This certainly did not show promise of a great aerial army. No one on this side had ever seen a battle plane, no one here had an idea of the necessary qualities of a prospective flier or of the intricacies of training required to turn out a pilot. Some system worked out along broad lines had to be developed quickly, whereby the whole revolutionizing of the United States air force would serve as a starting point. So it was, with what available information we could secure from our allies, that we began our air program. And so it was through the beginning of the fulfilling of this program, that on May 19, 1918, barely a month after the war started, six ground schools were opened, with definite curriculum except instructions to give three weeks of intensive military training while other details were being prepared. Thus the ground school came into being as the first big step in the large scale of training of American aviators. Immediately following this came the construction of flying fields, building of planes with which to equip them; hangers were constructed. Much valuable information for guidance in the building program, as well as for the training of aviators, was now being furnished by British and French officers who were beginning to arrive on this side from the front.

During the first six weeks of the war a small, but strong foundation was being laid, to meet the aerial program which was being put through with great speed, and seemed at this time as a balanced branch of a many sided military establishment.

Work on flying fields was begun in May, 1917, under the stimulus of the prospect that the first ground school graduates would be ready for their flying instruction in July. Along with the training of this first class, there were fields being selected and built, roads and railroads constructed about them, so that the first class of graduates could go directly to the flying field for their second step in instruction. Nearly five months had now passed since the beginning of the war but already great strides had been made in this branch of the service. However, compared with what was to come later, this beginning was small and was by no means as powerfully promoted as it would have been if the real needs had been foreseen. And soon we learned that the plans of the air program were entirely inadequate to meet the demands. We were spurred on by our allies across the water to try to achieve greater accomplishments, which were necessary if we were to compete with the damnable Hun who was at this time giving the allies a hot chase for air supremacy. So the previous plans of our Air Service program were completely shattered at the beginning of 1918. It was at this time that the mchinery was set in motion for an expansion unprecedented in history. France asked us to furnish 22,625 planes, including 12,000 types never seen here. Seven hundred million dollars were asked for, whereas the air service had, in all the years previous to the war, used only $16,000,000. Twenty-four flying fields to train 1,000 men a month, as well as supply depots, machine shops, and fields in France were needed. On January 1, 1918 we were to begin advanced training on 2,500 De Havilan 4's, and begin speed training on 800 each of S E. S.'s, Sopwith and Spad types. Besides this total of 4,900 planes, 12,000 service planes and 24,000 engines were called for by June, 1918, including 6,660 fighting planes, 4,000 reconnaissance and artillery planes and 1,333 bombers. All these, we must remember, were to be produced in from six to eight months. Thus the United States was called upon to carry out a program, which, if successful, would accomplish in one year, from practically nothing,



the building of an aerial force three times the size of that produced by France during three years of bitter war.

We can now begin to understand why we did not send over those ten thousand planes to fight the Hun, as was so foolishly promised in the big black headlines of our newspapers early in 1918. But unfortunately aviation had been slow in this country, and it was that romantic appeal to the American imagination that did a whole lot to help matters, for in this way demands for large appropriations were not so startling to the public mind. The Air Service was uppermost in the minds of newspaper correspondents and the public and both demanded information. The public soon became adjusted for the statements which were to come from Washington, which in ordinary times would cause intense criticism from the public. Editorials began to appear all over the country, all demanding a great air fleet and great speed in Congress. So when the announcements came from Washington to the effect that a half billion dollars were needed in addition to 40,000 planes and 10,000 aviators, they met with public approval. It seemed that the public was very optimistic and did not realize that the task was difficult. The set of mind had molded its form. But days passed into weeks and weeks into months and still the fulfillment of the early promises always seemed just over the crest, and was not forthcoming. Beyond all doubt these early promises were not all later fulfilled, but it is only fair to take all phases of the situation into consideration—the unfamiliarity of every one with the intricacies of the task; the obvious necessity for haste, and the temptation to be enthusiastic about a subject already dangerously romantic. But whatever be the grounds for criticism, the fact remains that an enormous program had been launched and the great aerial army, which later developed, had been set far ahead on its long road of preparation.

Up to the date of August, 1917, five months after the declaration of war, we had the new air program all made out. The problem of personnel for the great air fleet; pilots and observers, photographers, bombers, engineers, instrument repair men and the like, now opened up a wholly new and unexperienced line of work. No one had any idea how hard it would be to man an aerial army, or to the number of ways of science and organization the work would lead. Plans were drawn up on as comprehensive a scale as possible, always subject, however, to radical changes in an endeavor to cut corners and keep abreast of an almost impossible schedule. But in spite of this, it soon became evident that the proposed number of planes could not be manufactured in the time available over here. So in order to evade the holding up of the training of cadets in flying many were sent overseas where the hopes had been offered for overseas training. But here, too, there was an insufficient number of planes to take care of the cadets. The problem of primary training also wavered back and forth. Motor mechanics were needed, orders came for thousands of spruce timber men, bricklayers and construction men were needed. Schools for the training of seemingly every avenue of employment were opened. By May 1, 1918, 10,000 men had been sent, within six and a half months, through different schools, and the immediate pressing needs, both different schools, an dthe immediate pressing needs, both for overseas and for flying fields, had been met.

When we see in figures just what the vastness of the training scope was, we are much more impressed. By the termination of hostilities 414 bombing pilots, 329 bombing observers had been graduated. Nine hundred seven aerial observers and 1,192 pilots had been graduated, of which number half were overseas. The aerial gunnery ground schools equipped with 341 planes and had a total of 2,295 graduates. One thousand five hundred sixty-seven aerial photographers were graduated from the aerial photographer's school at Rochester. As a result of increased facilities provided for in the radio training, there were

240 radio officers, 369 privates and 780 mechanics turned out at these special schools. At the termination of hostilities 7,661 mechanics had been graduated and 1,729 more were in attendance.

Now to return to the flying fields. In the net-work of thirty-one fields scattered over the United States there was going on daily an amount of flying unprecedented in the history of the world. A total of 403,073 hours were flown in a period of less than four and a half months between June 30, 1918 and the signing of the armistice, in comparison to 407,999 hours flown in the whole year previous. Figuring this at eighty miles an hour, Americans in this country made over 32,000,000 miles in air travel in a little over one-third of a year and over 64,000,000 miles during the war period. Overseas figures show that on November 6, a few days before the armistice was signed, 77,726 men of the Air Service had actually arrived overseas. Of these 20,003 were with the A. E. F. in the zone of advance, and 32,561 were in the supply service; 4,134 were with the French in the zone of advance, 515 were with the British Expeditionary Forces; 20,162 were in England; 49 were in the Italian zone of advance and 122 in the Italian supply service. At the termination of hostilities the Air Service in France included in the zone of advance 2,161 officers and 22,351 soldiers, a total of 24,512 at the actual front. With the French army there was detailed eight American flying officers, and with the British Expeditionary Forces were 49 officers and 525 soldiers. The total personnel in France consisted of 6,861 officers and 51,229 soldiers, a total air strength of 58,090. Air Service mechanics with the French army included 109 officers and 4,744 soldiers. Nineteen months before, it may be recalled, the total Air Service numbered 1,185 officers and men.

Thus we have the American Aviator appearing over the trenches in every sector from the North Sea to the Adriatic. Their part, although not decisive in the extreme degree of which early American optimism had given hope, was, nevertheless, important in effecting the amazing sudden crumbling of the enemies' forces and led to the assurance of an early Allied aerial supremacy.

All these achievements were not manifested, however, without their price. Many precious lives were lost in the preparation of this aerial army. Up to November 11, 1918, a total of 278 men made the supreme sacrifice at flying fields on this side. This well advertised danger did not, however, mar the young Americans' ambition to attain single honor and fame. Applications for flying service were received by the thousands. At first the very flower of American youth came forward, but later the quality began to fall off with the drawing of the first enthusiasts and the attraction of other good officers' training camps. The task of sorting the desirable applicants was recognized from the start as one on which the efficiency of the Service rested. As a result a net-work of examining boards was set up all over the country. Consequently the examination was most rigid.

Each man's general character, athletic ability, agility of mind, and past record were gone into as carefully as possible by a main examining board to see if he appeared to be of the aviator type. Those who were awkward, sluggish or slow were not accepted. After tests of heart, lungs, and blood pressure came tests for obstructions in the nose and throat, which might be a danger to a man passing through wide range of temperature. Severe eye and hearing tests were also given. Most unusual, however, was the balance test in which the candidate was spun rapidly around in a revolving chair and then put through certain reaction tests which were definite tests of how the person would act under similar flying conditions. It seemed practically every part of the body was given more or less examination. So severe were these examinations that practically one out of every two candidates was thrown out. Eighteen thousand four out of 38,770 were rejected. These tests which were standardized, contained possible mistakes, but it is safe to say that much grief and expense was saved by stopping at the gates, men temperamentally or physically unfit.

The first assignment of successful candidates was to one of the ground schools, previously described, where the cadets were trained in what was at first a three weeks' course, later increased to eight and finally to twelve weeks. During these periods the cadets received instruction in the theory of flight, radio, codes, aerial photography, meteology, gunnery. Plenty of drill and calesthenics were given along with the studies in order to keep the cadets in the best physical condition. One of the most interesting studies and probably one of the most interesting devices was the "miniature range," which viewed from a balcony above exactly simulated a sector of a battle front. The cadets seated aloft as in a plane "spotted" various lights made to flash on and off on the range, and developed speed and accuracy in observation, and in wirelessing their information to the instructor, who signaled the lights from a duplicated map chart and checked the accuracy of the cadets work. Lots of sport was had at the ranges shooting at clay pigeons, which helped to develop quick and alert action spotting an object with a gun.

Along with these minor sports went a lot of good earnest work. The instructors spent sweltering summer months working hard upon the minds of the young men, trying to teach them all that was possible to teach about aeronautics in the short period of twelve weeks. At these ground schools the consolation of the instructors was not only the rendering of a service to their country but the eagerness and responsiveness of their pupils. It was a college in which the ordinary vexations of class room work was unknown. The careless young man was here settled down upon a hard and arduous task, a task about which he was serious in order to gain an education pertaining to aeronautics. Class room cuts were not tolerated and the professor who extended his lecture for two or three minutes overtime was not made acquainted with the fact by the monitory scraping of feet. In stead the pupil sat stiff as a ramrod, quietly recording in his neat note book every word of the professional wisdom. The point was that "flunking" here had quite a different meaning than it had ever had before. Occasionally a student failed, and the penalty was sure and swift; he was dropped from the class and his career as an aviator came to an abrupt end. The student who, in ordinary college life, did not worry about those "letters sent home," or about suspension or failure to receive his degree, now had a wholesome dread of being found unworthy to serve his country, and likewise dreaded to bring to a smashing end all of the high hopes of ever being an aviator, which thought had probably been spurring him on so earnestly in his work. Or perhaps he knew, too, that if he failed that he would have to go back to the organization from which he came and there be the same unrecognized doughboy. Hence this atmosphere of rapt interest in such subjects as velocity, the lifting power of the wind and the mysteries and invisible movements of the air.

The second step inculcated in the life of a cadet, if he was fortunate enough to evade the torturous "Battle of Camp Dick," (Dallas, Texas), was to be taken to one of the large new flying fields, and it was not until the cadet reached this stage that he was really glad he had chosen this branch of the service.

Different methods of instruction were followed at different fields but the two main systems were the "All Through" system, that one in which the cadet was in charge of one instructor during the whole primary training period in flying, and the other system which was carried through in different stages, first dual, first solo, second dual, second solo, etc. Either system was entirely worked out with the utmost care and minute detail, with every hour filled with work and every source of danger guarded against. From the very beginning the training of fliers was prescribed with the utmost care, leaving just as little chance as possible in a science in which so much depended upon the individual. Step by step the cadet went on, always held back it seemed, and often needlessly, until he was double skilled in the present phase of the work and doubly eager for the next. In the early days of flying, however, this was not always true. We had not had experience as a teacher and it seemed that the idea prevailed that all a person needed in order to be able to learn to fly, was nerve. He was "cut" loose early with a ship and took his chance. If he made a successful flight he was a flier, if he broke his neck he was considered as being no good in the first place.

The first ride in an aeroplane is an experience not soon to be forgotten. It is supposed to be a sort of a joy ride, so that the cadet may be given an opportunity to accustom himself to the "feel" of the plane. And too, it is desireable to make a favorable impression upon the cadet toward flying in the early stages of the training. If the cadet is taken up and churned about on the first ride he may be entirely scared out of the notion of ever wanting to fly again. Almost without exception, however, the cadet is at once alarmingly surprised with the simplicity of it all and begins to gain confidence from the start. My first ride I will never forget. I had reported to a certain instructor with four other cadets for my first ride. Each of us was assigned a turn to fly with the instructor. I was to be the second one up so my wait was short, and glad I was, for during the thirty minutes before my turn came, it seemed I was thinking about how wonderful the ride would surely be. I tried to imagine myself sitting in the cock-pit, and wondered if I would get dizzy or sick and how the earth would look below, and how it would seem to be hurled through the air at such great speed. I was much relieved when the instructor signaled for me to come to the ship he had taxied up. I climbed into the rear cockpit of the ship, a standard training plane, and proceeded to strap myself in. After asking if I was all ready the pilot adjusted his goggles, peered over each side of the ship to see if all was clear in front, pushed the throttle wide open and we were 2off. What happened in the next few minutes came entirely too fast to try to relate. Soon however, I noticed the earth falling away and now began the first sensation of my flight. At once I began looking down and noticed how wonderful everything looked below, the small domino shaped buildings and checkered fields, the white lines outlining the roads and creeks. Instead of experiencing the sensation of a great speed as I had expected the ship seemed to be moving along very slowly. It was hard to realize that we were traveling close to ninety miles an hour at times. Up and up we went until we came into black walls of mist. No earth could be seen now, and at once my mind was diverted to the deafening roar of the motor, and how powerful it seemed and how helpless I myself felt. I could not ascertain whether we were moving, side slipping or standing still, it seemed so smooth, until, by putting my head over the edge of the cock-pit, the wind pushed in my face with a great force. We were only in the clouds a short time and soon were into the bright sunlight above. I had not been admiring the wonderfulness of it all but a short time however, until my instructor cut off the motor and, turning around to me, made a motion with his hand and said "tail spin, watch the controls." The ship for a second seemed to almost stop, it swerved, quivered, and then, bang. down it went. The clouds had cut loose and were spinning above, around and under us. The only reason I didn't swallow my liver was because I couldn't catch up with it. About the time I had gained enough control of myself to remember I had been instructed to watch the controls the instructor straightened the ship out and, turning around, asked me how I liked it. I was too dumbfounded to even try to talk, but I was quite sure that I was not feeling at all at home. By the time we had gained altitude again I was almost normal. Right and left hand spirals were the next thing tried, during which time I would barely get the earth located on one side of the ship, and then it would disappear and come up on the other side. By this time I was wondering if I would ever become master of the situation and really be able to pilot a ship. Finally, after giving me a few details, my instructor asked me to put the ship into a tail spin. The first attempt was a failure. About the time it seemed to me to be falling at an enormous speed I began to put the controls into what he called "neutral" and the ship straightened out. The second attempt was better; we went spinning round and round down into the clouds. By this time I was beginning to feel pretty well churned up, and something was gnawing at the muscles of my throat to get out; my instructor pulled the ship out of the spin and although I had a hold of the "joy stick" it seemed to me I was trying to balance myself on a point and liable to fall off at any moment. I had surely had enough ride for the first time and felt much relieved when were gliding down through the clouds with the wires singing and the water streaming from the wings. Below the clouds the home field was seen not far off. Soon the earth appeared to be rapidly pushing up to meet us and just in a niche of time the ship gracefully flattened out its glide and the tail skid striking the earth soon brought us to a stop. My first ride was over. The next five hours were spent with instructions in practicing landings, take offs, banking and gliding, during which time I was informed several times to the effect that I was far from an ace. At the end of this period my instructor climbed out of the ship and asked me if I thought I could take the ship around alone. I had gained enough confidence in him to know his judgment made him feel justified in turning me loose, and even if he did not care for my neck, I knew he was held accountable for the ship. Here the second big sensation of flying came to me. My mind was completely submerged in applying those principles which I had been taught and I was very conscious of the fact that the ship would respond to the way in which I controlled it. There was no room in my brain for thoughts of fear. After making the take off successfully, followed by the first and second turn, I was sailing along on the back stretch of the field when something suddenly seemed to tap in on my mind to remind me that I was all alone, doing this feat by myself. I soon began to experience a new feeling of confidence in myself. Nevertheless, this feeling of confidence was interspersed with a timidity which limited my aerial achievements on my first ride alone, especially when I noticed the ambulance, or so-called "meat wagon" down there on the ground, which just seemed to be waiting there for a chance to come and mop me up. Anyway I made the next turn all right, and shutting off the motor "nosed" down toward the ground and made a good landing. I don't believe I would have felt any more puffed up over myself had I just brought down my first Hun. The ship had hardly come to a stop, however, until my instructor, who had been standing off to one side watching me all this time, gave the "high ball" to go ahead again. I had thought perhaps he would come over and compliment me and tell me what a great flier I was: I learned that officers didn't do things that way.

We were at the fields for flying training and it came fast and rigorous. There was no time to be lost. From this time on just as soon as one thing was learned well something new was added. Often, however, new things came too slow and old things became old too soon, so we were tempted to do stunts whenever the opportunity presented itself. This was especially true when away from the home field and where we were not liable to be caught up. It was a temptation that could not be resisted, to "jazz" around close to the ground, chase the trains, dive at automobiles, or "flirt" across a farmer's front yard, and sometimes "there was a reason" too, for the latter. It became more or less monotonous to fly high all the time, up there where there was no one but oneself; thus the eagerness for low flying, down where "people lived" so to speak. It was this fool-hardiness of trying new stunts that cost so many lives at the flying fields and strict rules were enforced to forbid such practices as much as possible. Thrills can be found if sought, or hours can be spent in the air as monotonous as guiding a truck along an uninteresting country road. There were thrills galore to be had in "stunting" and this was the greatest sport in the whole flying game. Many unpleasant experiences come to pass, too, during the flying career, but all these only tend to increase the confidence of the pilot, since his judgment has each time been master of the situation, and brought the plane to earth, and still been able to tell about it. After all, the flying game is not any more dangerous than some other occupations in life if considered outside of actual warfare. In spite of all precautions, in spite of the most stringent regulations, fatalities proved unavoidable, some due to dangers inherent in the abnormal flying required in warfare, some due to purely human weaknesses in the fliers. Up to November 11, a total of 278 men made the supreme sacrifie on this side. Averaging this number against the total of 811,072 hours flown gives a fatality for every 2,960 hours or 236,800 miles, a very much more favorable record than similar figures for fliers trained in France and England, or by the Canadian authoities in Texas.

Thus we have the Air Service today filling a far greater common place than it did only a few months ago. The war served to do all this. It brought the air man down to earth, so to speak, and made him human. Before the war an aviator was looked upon as a dare-devil, to be seen only on special occasions. The recognition of aviation as a means of offense and defense has changed all that. The aeroplane caught the popular fancy. The air man became the modern hero. To be an aviator was the thing of the hour. The result was that soon the man with a pair of wings on his breast was frequently seen. People no longer turned in the street to stare at him. There is something fascinating about flying which seems to create a change in the person who has flown, as seen through the eyes of the person's friends. The flier has acquired a something that has made him different. He is not the same man. So upon our return from the service we have many questions put to us by our friends. No one question is asked more often than this, "How does it feel to fly" and the answer given depends on how the flier feels at the time or by whom the question is asked. If asked this question by a lady friend he may answer with thrilling and hair-raising stories, while if he feels like clearing the question at once he may say that it is in direct simulation with driving a car. The answer to this question is not as easily given, though, as the person who asks may think. It is the "feel" of a ship which one has to acquire before he becomes a successful flier. It is this sense of "feeling" that develops the automatic human control which develops in the aviator, and it is not easy to explain just what this "feel" is. It is this sense of feeling, however, by means of which we can tell in what position the ship is "hanging." It is a quality which is supposed to be determined by the medical board with their whirling chair. Some who did not have this quality did get by but they were few. This was one place where the old fogy idea of sizing up a man by his appearance did not hold. I have known men, athletes, and with every mark of courage and determination upon them, give up their attempt to learn to fly, while others, small men, altogether unimpressive in appearance and with weakly looking faces, would prove to turn out the most expert and daring fliers.

In this war romance has played a big part. The lure of adventure has drawn together a class of men from whose ranks most of the modern heroes have emerged. It is this type of man, the adventurer, who seems to make the best type of flier. It is the sensative man, who has the touch and sense of balance that enables him to fly and perform maneuvers instinctively, without knowing just how he does them. In fact there were nearly all types of men in the Air Service, some were dare-devilish, some flew by a mechanical process, that is, thinking every time they moved the controls, and others were conservative fliers. It was by these three qualities that fliers were classified as pursuit pilots, bombers and reconnaissance fliers.

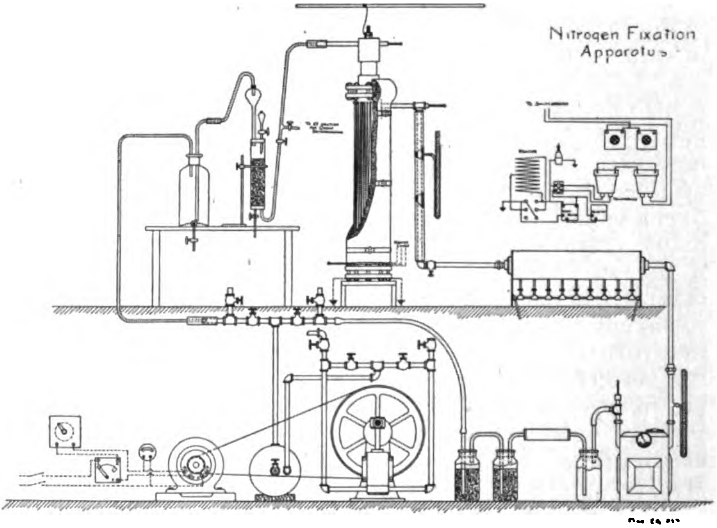
Out of these classes of fliers we have at the close of hostilities 63 aces emerging, seven of whom were killed in action. The total number of aviators killed in action on all fronts was reported as 150. Add to this the lives that were sacrificed on this side and at once the imagination leaps with inspiring awe and remorse. Let us not fail to appreciate the fact, however, that this sacrifice was not in vain. America dedicated herself to the conquest of the air. In order to accomplish the myriad difficulties which confronted her in trying to carry out this resolution of gaining air supremacy a few dark pages were sure to be recorded. A superb record of successes, however, was attained in the end. The necessities of war speeded the development of the aircraft enormously. Ten times as many years would not have produced the same advance if the years had been devoted to peaceful pursuits and commercial uses of aeroplanes had been the only incentive to inventors and producers. With the great start made in a little more than nineteen months, it seems, that with the perfections of aeroplanes, new possibilities of use will be discovered, until it is difficult to restrain ones forecasts of what the future holds in store. The possibilities are limitless.

A PROCESS FOR THE FIXATION OF ATMOSPHERIC NITROGEN

By K. B. McEachron

INTRODUCTORY

For many years investigators have been trying to find a cheap method for the fixation of the nitrogen of the atmosphere. Several different methods have been developed for doing this, but none of them could be described as being cheap. A brief sketch of two of the most important processes will be given.



In the so-called Haber process, nitrogen obtained from the air is combined with hydrogen in the proper proportions to form ammonia. The ammonia thus formed may then be converted into whatever form is required. For the Haber process the nitrogen is obtained from the air by the method of fractional distillation. Oxygen is a by-product of the distillation process. The necessary hydrogen may be obtained electrolytically or as a by-product of various chemical processes. The hydrogen must be pure as traces of oxygen, sulphur or hydrocarbons destroy the effect of the catalizer used when combining the nitrogen and hydrogen. The ammonia is produced under a pressure of about 150 atmospheres and at a temperature of from 500 deg. to 600 deg. Centigrade.

The Haber process, while quite expensive, has probably been used more than any other during the war.* The United States government built several plants to operate on this principle, in order that a sufficient supply of nitrates might be insured for the manufacture of explosives.

If air is heated to a sufficiently high temperature (2000°C.) an appreciable amount of nitrogen and oxygen combine to form nitric oxide (NO). This temperature is secured by the use of the electric arc. The manner of producing the arc has given rise to several differently named arc processes. The problem seems to be one of finding the way to secure the most intimate contact betweet the arc and gas, and then to cool the gas as quickly as possible. The cooling is necessary because the NO is not stable at the temperature of the arc, and so must be cooled rapidly to prevent dis-association.

The NO formed is allowed to pass slowly through large towers, where it is oxidized and absorbed, the final product being nitric acid.

The first cost and operating expense of both the Haber and the arc process are quite high, and on this account an investigation has been undertaken at Purdue to develop a process which would produce the required nitrates more cheaply.

SILENT DISCHARGE

If a conductor is charged with a sufficiently high potential, a glow will appear surrounding the conductor. If this discharge is maintained in the air for a short time a peculiar odor will be noticed which has been found to be (O_3) Ozone. Apparatus for the production of ozone has been developed on a commercial scale. The ozone is an excellent oxidizing agent, one atom of O being given up very readily. Thus if ozone could be brought into contact with atomic nitrogen, nitric oxides would form as a result. It would seem that the same agent which breaks up the molecular oxygen would do the same for the nitrogen, although requiring somewhat different conditions. That this is true has been ascertained by experiment.

Quite a little work has been done on the production of ozone, with both alternating and direct current. It appears to be well established that the direct current discharge is not as efficient as that formed by the alternating current.

That this discharge called the silent discharge or corona would produce nitric acid in the presence of water has long been known. In Austria, Dr. Hugo Spiel did considerable work in 1910 on the production of nitric oxides by the discharge of a large induction coil. In this country many observers have commented on the corrosion of wires on transmission lines, especially at the tie wires where moisture may remain for short intervals.

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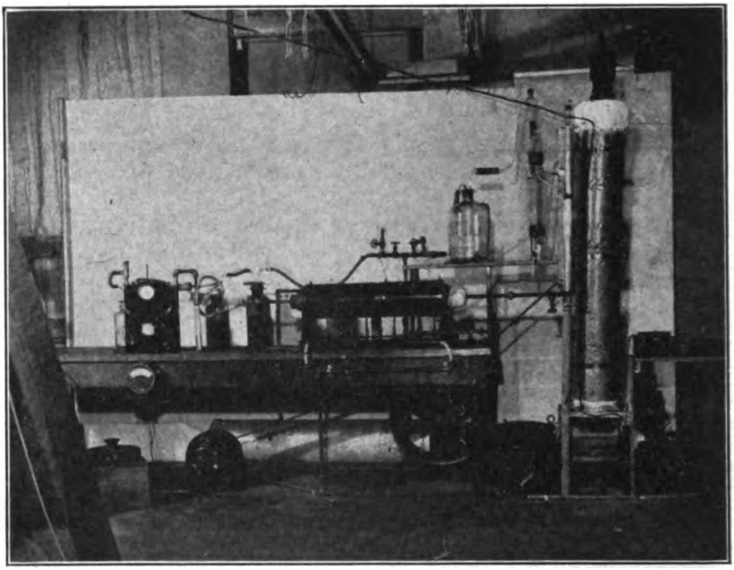
*The cyanamid process was also largely used.

The problem to be investigated at Purdue then, becomes one of finding the most favorable conditions for the production of the N_2O_5, which is formed by this process, rather than NO.



THE APPARATUS

The discharge tube consists of an aluminum tube 6 inches in diameter and 5 feet long. This tube is connected to the ground through the ammeter and wattmeter used to measure the current and the power taken by the tube. An aluminum rod ⅝ inch in diameter, placed on the axis of the tube and connected to the high tension transformer forms the other electrode. A 3 inch porcelain tube ½ inch in thickness and 6 feet in length, placed coaxially with the aluminum tube acts as a barrier to prevent an actual power arc forming between the rod and grounded tube. The discharge tube is provided with apparatus for measuring the pressure of the gas in the tube and the temperature of incoming and outgoing air. A wrought iron casing has been placed around the aluminum tube to allow tests to be made at high pressures. Most of the work done thus far has employed a potential of about 50,000 volts at 60 cycles. With this voltage a strong discharge may be seen through the plateglass bottom of the tube. At low pressure the discharge is of a deep violet color, no sparks or streamers being observed. As the pressure is increased, sparks begin to form at the inner electrode until finally at a pressure of a little above that of the atmosphere, the tube is filled with these sparks.

Absorption apparatus consisting of an absorption tower containing NaOH was used for nearly all of the work done in the past. Some improved absorption methods have been worked out, which give very intimate contact between the gas and the absorbing liquid. These are still in the process of evolution, however, and will not be described here.

The NaOH tower as constructed was quite satisfactory. Instead of using glass beads to break up the bubbles of gas, short lengths of 4 and 5 millimeter glass tubing were used. This gave a large wetted surface with very little back pressure.

A view of the complete apparatus is given in Figure 1. Figure 2 shows the scheme of operation. A motor driven air pump supplies the air to the system either above or below the pressure of the atmosphere by. a simple manipulation of the valves.

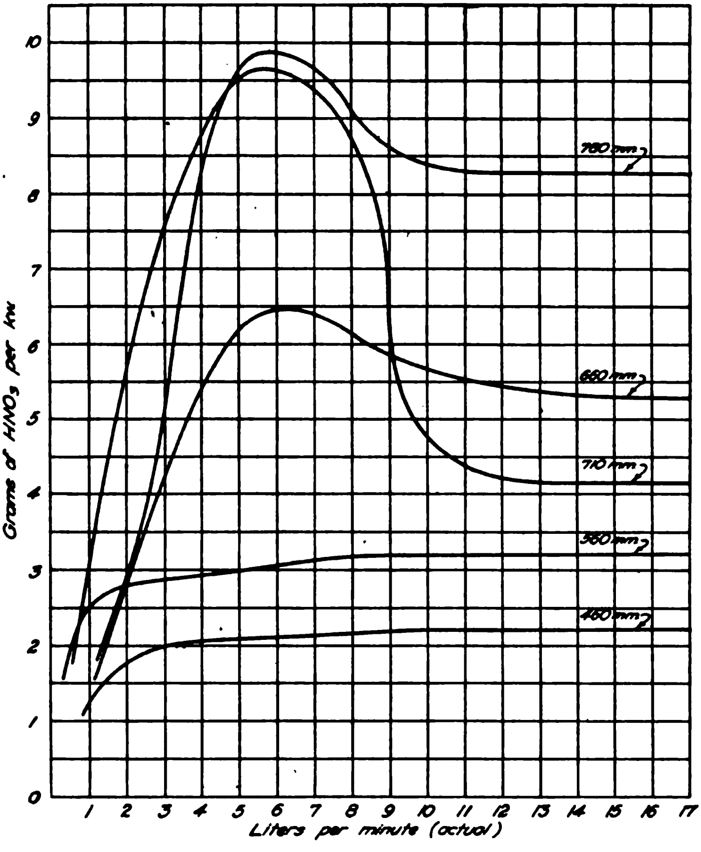
The air then passes through sulphuric acid drying chambers, a soda lime chamber, and settling chamber into the air meter. This air meter is of special design so that one revolution of the pointer indicates one cubic foot. This meter is of the bellows type and very satisfactory for the purpose.

After leaving the air meter the air passes through an air heater, where the air may be heated if desired. The air is then conducted to the discharge tube, absorption apparatus and finally discharged to the atmosphere.

The power for this investigation has been supplied by a 200,000 volt transformer of about 50 Kw. rating. Suitable meters are connected in the primary and secondary circuits of the transformer.

RESULTS

About 120 runs have been made using this apparatus. The time of the run in most cases was 45 minutes. Due to the large number of variables, some of which are air pressure, air velocity, temperature, humidity, voltage and frequency, it has been quite difficult to work out a plan of operation so that results could be duplicated. This difficulty however, has finally been overcome.



Series of runs have been made at pressures of 460, 560, 660, 710 and 780 millimeters. In each case the pressure was held constant and the air velocity varied. Some interesting results have been obtained. The curves which are given in Fig. 3, show that the yield per kilowatt-hour increases as the velocity increases, and also as the pressure increases. The falling of the curves at the higher velocities has been shown to be due partly to the poorer absorption at these velocities.

The highest yield shown by these curves is 9.8 grams per kilowatt-hour. This value is about ⅛ of that obtained by the arc process. We have, however, data from tests not yet ready to be published which have shown that a material increase in yield may be expected from better absorption.

At certain air velocities and pressures a very dense white fog is formed over the surface of the absorbing liquid. This fog has been collected and has been found to contain some nitric acid. Thus the collection of the fog becomes a part of the process of absorption. The heavier fog particles are collected in a device where the gas turns a sharp angle at a high velocity—The finer traces being obtained by the use of a Cottrell precipitator, using high voltage direct current. The concentrations secured by the silent discharge process are less than one-tenth of that found in the arc process, but the absorption is easier as the product is N_2O_5, not requiring any further oxidation to produce the nitric acid.

There have been several incidental problems arise in connection with this work, which will not be discussed here.

CONCLUSIONS

From the work done thus far, there does not seem to be any reason why the yields cannot be increased very considerably.

The yield depends on pressure and air velocity, and increases with an increase of each, within the range investigated.

The process would require in a commercial plant a smaller initial expenditure than that required by either the Haber or the arc process.

The maintenance of a plant operating on this principle would also be less, as very little in the way of replacements are required. The porcelain tube is, of course, subject to break down but from the experience we have had a good tubes should last several months. However, no definite data on continuous operation is available at the present time.

This investigation at Purdue began originally as a subject for senior thesis, and was later taken over by the Engineering Experiment Station.

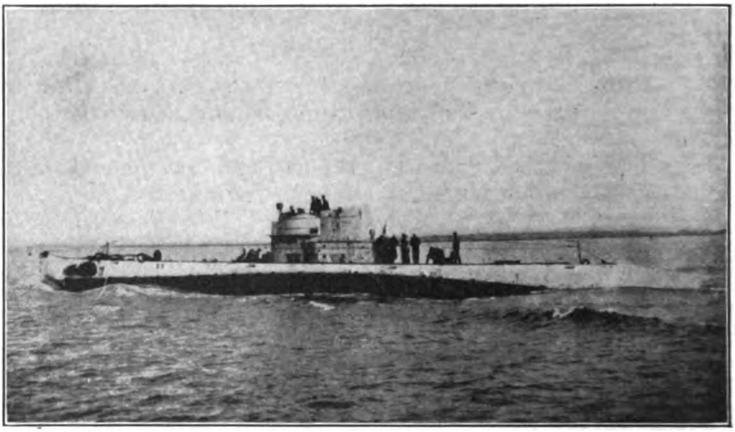
"WHAT SHIP, JACK?"

(A story by which one might picture himself taking a trip through one of Uncle Sam's submarines with a friend, who is a member of the crew. The adventurer claims that the inside of the submarine is the most intangible, heterogeneous, perplexing and complicated arrangement of pipe lines, valve wheels, levers, switches, gages and fixtures that he exer expects to see in this world or the next.)

Written by an Ex-Submarine Gob,

R. A. Whitford, '20

"Hello, Jack! Let me keep my promise and show you through the Submarine to which I am attached. Take off that white uniform and put on your dungarees. This is no place for dress suits. We will not inspect the boat from stem to stern.



"Let us go down through the forward hatch into the torpedo compartment. Steady, and don't slip, as the deck is icy. Forward, where you see the four doors, are the torpedo tubes. These are fired electrically. A charge of compressed air gives the whales their initial velocity. They are self propelled after they leave the tubes. Below the deck under th tubes is the forward trim tank. On the port side is the oil manifold, where the fuel oil is taken in from the outside. The motor in the center of the compartment, operates the deck anchor and the submerged anchor. Just forward you see the cable cutter which is to cut the latter away, in case a 'quick get away' is necessary. We carry four extra torpedoes, besides those in the tubes. In those five tanks below the deck we carry distilled water. This is used to fill the batteries. The bottles along the side, constitute the air banks which we keep charged at twenty-five hundred pounds pressure.

"So you recognize the odor, do you? This is the forward battery compartment. Under the deck there are sixty Lead-Exide Batteries; these weigh eleven hundred pounds each. Between the batteries and the hull is the forward-main-ballast tank. We must be quiet while in here as the second officer is asleep in his quarters. The crew's lockers and bunks are also in this compartment. As you can readily see, the lockers do not hold very much. This is the compartment that was nearly cut from the rest of the boat when we were rammed by a British Tramp Steamer, which mistook us for a German submarine. Just opposite is the Gyro-Compass and its control board. Yes, those fans are for ventilating the batteries; they draw the gas from the battery tank below and discharge it overboard when on the surface, but discharge it in the boat when submerged. You can imagine the disagreeable odor that fills the boat after being submerged for sixteen or eighteen hours.

"The next compartment aft, is the central operating, known as the brains of the ship. From here the boat is operated, when under the water. Forward you see the electric and hand steering gear. Those controllers on the port are for operating the main motors. In the corner is the one and one-half kilowatt radio set, and beside it the control for the bow and stern diving rudders. Above which are the forward and after depth gages. These were quite active one day, when after we had been fired upon, we submerged one hundred and eight feet without stopping for passengers. At your left is the air manifold. This is the high and low pressure air control for the entire boat. The air is used for blowing the tanks for coming to the surface, also for transferring water from one tank to any other tank. Be careful and don't bump your head on that periscope. There are two periscopes and one altroscope in this compartment. These are raised and lowered by compressed air. This compartment is also used by the officers for their mess. They can eat, keep their eye on the periscope and fire torpedoes at the same time. Those levers are for opening the sea-valves and are called kingstons. This is the electrically driven adjusting pump for the transfer of water either forward or aft. Under the deck where you see those pipes leading, are the adjusting and auxiliary tanks. They are located at the center of gravity of the boat, and are used in making final adjustments while submerging. The control panel you see on the bulkhead, is for the oscillator, which is a submarine listening and signalling device. Above you is the hatch leading to the conning-tower and bridge, where the boat is controlled, while cruising on the surface.

"Now we have come to the after battery compartment. Under the deck are sixty more storage batteries, which are a separate unit, as are the ones forward. Between the batteries and the hull is the after-main-ballast tank. Here on the starboard in the main switchboard, upon which is the main motor control circuit-brakers, for throwing the batteries in series or parallel. All lighting and power circuits are controlled from this board. The right-hand panel has the voltmeter ground detector on it, also the auxiliary circuits. Just behind you is the elevator periscope. By this apparatus, a person can be taken to the top deck level and do periscopic detection, while the boat is submerged at a depth of thirty feet. This compartment is also used for the crew's mess, the galley and sleeping quarters. The bunks are folded up, as you can see, in the day time. All the cooking is done on that electric range, and we have no trouble in getting our chow, unless the ship is rolling from forty to sixty degrees, which has actually been the case during a storm. On the after bulkhead are two ventilating fans, similar to the ones in the forward compartment. It has been pointed out that these were the cause of a very serious battery explosion that took place in the latter part of 1918. The third officer was killed instantly, the captain so badly injured that he died three days later and the electrician that was 'standing by' for me had both of his legs broken and his skull fractured. You are right Jack, I was certainly lucky, in that I was off of the boat at the time.

"The next compartment aft, is the engine room, as you can se at a glance. Those two Semi-Dietsel oil engines are four-hundred and forty horse-power each. They rotate in one direction and are capable of driving the ship at fifteen and one-half knots per hour on the surface. On either side, next to the hull are electrically driven pumps for lubricating oil, fuel oil, and circulating water. One set of pumps for each engine and each set interchangeable. Yes, the oil tanks are under the deck. Just forward, you will notice on either side the main motor control contact panel boxes, and between them are the main motor controllers. These are duplicate to the ones in the central operating compartment. Just astern of the engines are the main clutches, which are operated, when throwing the engines on or off of the main line-shaft. Seven men nearly lost their lives in this compartment one day, when a vaccum was created by the engines, due to the air supply being accidentaly cut off.

"You will notice that the line-shaft runs aft, through the next compartment, where the main motors are located. The armature shaft of each motor is directly connected to its respective main line-shaft. These two motors are three hundred and seventy horse-power each, and are capable of driving the ship at nine and one-half knots per hour, when submerged. They also may be run as generators by the engines for charging the batteries. In the center of the compartment you will notice two direct connected eonnected electrically driven centrifugal pumps, one a high and the other a low pressure pump. Just aft of these are the three-stage air compressors, one connected to each line-shaft by means of a clutch. These are for charging the air-banks that you saw in the torpedo compartment. Yes, those are the thrust bearings, they are between the main shaft and the tail shaft. The lathe you see, is used by the machinists. The after-trim tank is located in the extreme stern.

"There are many other parts of the boat that I would like to show and explain to you, but Uncle Sam requires that his Submarine men keep these things confidential.

"Yes, it is just 4 o'clock and your boat 'shoves off' at 5:30. I will see you in Cuba this winter. So long, and give the boys on the U. S. S. New Mexico my regards."

PURDUE IN GAS DEFENSE SERVICE

H. H. BEATTY, '17

Six weeks before graduation in June, 1917, after it was found impossible to enter the First Officers' Training School at Fort Benjamin Harrison, Indiana, the writer was employed by the Aluminum Company of America at their New Kensington, Pa. plant, in their Laboratory and Research Department, under the direct supervision of Mr. E. Blough, Chief Chemist. Mr. Blough was later an active member of the Aircraft Standards Board.

Immediately we were actively engaged in the production of an aluminum alloy suitable for use in aircraft construction, and it was principally in this work that the writer was engaged until his enlistment in the United States Army in December, 1917.

Research work on various aluminum alloys had to be accomplished with all possible haste, due to requests from the U. S. Government for a light alloy with the proper physical properties for use in aircraft construction work. It was the undersigned's work at that time to investigate as many light alloys as possible, and in the course of the ensuing few weeks many alloys of aluminum were investigated before one was found which was thought suitable for the Government's requirements. These experiments consisted of testing the alloys under investigation physically and chemically. The writer had charge of all the experiment work in the laboratory which included devising methods for heat treatment and physical testing. The exact nature of the work, nor the composition of the alloys which were investigated before a suitable alloy was found is of such a nature that this information will have to be omitted from this article.

Following the choice of an alloy the production of aluminum sheet on a commercial scale was the problem which had to be solved inasmuch as it is a very difficult problem to cold roll certain of the aluminum alloys free from numerous surface imperfections. The writer was active in this work. As soon as the material was being produced in sufficient quanitities the construction of triangular all-aluminum alloy girders was begun. Various tests on the completed girders were conducted at the Laboratories and other finished girders were sent to the U. S. Government for final tests. Girders up to 30 feet in length were built. They were exceptionally rigid and of course very light in weight.

Since these girders were to be used in the construction of aircraft every ounce of metal making up the finished product was rigidly controlled in the process of fabricating the aluminum alloy sheet. Every step from remelting the raw materials, and making the raw alloy to the final rolling of the finished sheet required very close supervision. The slightest deviation in any one of the intermediate processes prior to the final operation would be liable to cause complete rejection of that run or lot of metal. Technical control was absolutely essential in the manufacture of this type of product.

Besides being actively engaged in the production of these girders, the writer had considerable experience in plant control work in connection with the manufacture of the aluminum canteens and meat pans which were being made for Uncle Sam.

The Gas Defense Service of the U. S. Army, which was organized but a few months prior to December, 1917, issued an urgent call for men at this time. The writer enlisted in December, 1917, and was stationed in a Gas Defense Laboratory in Washington, D. C. The problems confronting this particular division of the U. S. Army were more closely allied to the chemists' profession than to the engineers'. While in Washington the toxicity and composition of various war gases were studied, preparatory to future work to be done on a much larger scale at the Shell Proving Grounds, Lakehurst, N. J. However, after six weeks in this gas defense work, the writer was transferred to the Medical (Physiological) Research Division of the Gas Defense Service, stationed in New York City under Dr. Yandell Henderson of Yale University and Captain Howard W. Haggard, also of Yale University, and given charge of a chemical laboratory in which laboratory the various blood gases had to be analyzed. Experiments were conducted on live dogs, which experiments had a direct bearing on the numerous aviation problems, "shell shock" and hemorrhage. The investigations which first commenced on a small scale gradually grew in size until it was found that larger laboratories were required. The detachment was transferred to New Haven, Connecticut, where more spacious laboratories were available. Investigations in earnest were conducted on much larger proportions concerning the many physiological problems confronting aviators who must fly to very high altitudes. A great deal of work was also carried out along the channels of, the cause, the effect and the cure for shell shock as applied to soldiers suffering from the so-called "shell shocked" condition. Here in New Haven, the writer had complete charge of the chemical laboratory until the war had ended.

Fortunately this Chemical Warfare Detachment was scheduled for overseas duty early in the spring of 1919 and it was a disappointed company when the news reached New Haven that the armistice had been signed in November, 1918. The detachment was demobilized early in January 1919 and once again we turned to our civilian work, feeling at least we had done a part of "our bit" in the World War.

PURDUE IN THE ENGINEER CORPS

PROF. ALBERT SMITH

More than any other profession, Engineering develops in its practitioners a capacity for modern war work. All of the machines used are familiar to them in theory and practice, all of the construction is like that of their daily work. More important still, the planning of operations, correlating resources of labor and material, is in itself so like the planning of military operations, that the Engineer is almost a soldier when he enters the service.

The Engineer's qualities make him valuable in any branch of the service. There is no branch, except perhaps the theological, from which it is easy to secure transfer to the Engineers.

Vast as the expansion of the Army was in all lines, the expansion of the Engineer service was much the greatest. From five hundred officers to many thousands, from a few battalions to several hundred thousand men, the expansion was so great that the existing organization was scarcely a pattern.

The Engineer work may be divided into—

Sapper Service.—Combat troops used in front line fortification, roadmaking and bridging.

Pioneer Regiments.—For Engineer work just behind the front lines.

Service Battalions.—Engineer labor in the S. O. S.

Special Regiments.—For railroads, water supply, power lighting, roads, forestry, etc.

The country depended upon the existing body of practicing engineers in civil life to officer these organizations, and was not disappointed.

About three hundred Purdue graduates and undergraduates served in the Engineers. Two were killed in action, four others died in the service, four were decorated, and many were cited in order for gallant and efficient service.

It was a Purdue man, Swan, who was decorated for bridging, with his battalion, the Meuse in the face of the German defense. A volume could be filled with accounts of the courage and devotion of our men in this service.

More Purdue men went into Engineers than into any other branch of the service. If we include also the Signal Corps men and the large number of men in Quartermaster construction, Ordnance, Chemical warfare service, and naval construction, we shall include a large majority of the Purdue Engineers in service.

This is as it should be. Other services may be carried on by men of other professions, but the Engineer service demands Engineers, and must have them if it is to be efficiently conducted.

The graduate Engineer should regard himself as always potentially a soldier, and at the Country's call.

One of the finest of many examples I know of the Purdue spirit in the war, occurred in the winter of 1917. There appeared at an army divisional camp, a young man who asked to be enlisted in a sapper regiment. He gave his education—Purdue—his experience—engineering in Chicago—and passed a good physical examination. Upon looking over his record, it appeared that he had lately given up a fine position in Chicago. The surgeon found that he had undergone, at his own expense, a severe corrective operation to enable him to enter. This man was interested in his work, liked his issue uniform and enjoyed his food. He proved to me that a man can look like a patriot and a gentleman, even while peeling potatoes. It does not increase one's admiration for his attitude and conduct that within two months he rose from enlisted man to first lieutenant. That simply shows that the army boards were intelligent.

There were many others like him. They have reflected honor upon Purdue.

PRODUCTION WORK AT NORFOLK NAVY YARD

By PROF. G. H. SHEPARD

During the war I was engaged in production work at the Norfolk Navy Yard. This is our second largest Navy Yard and had important stragetic relation to military operations, because Hampton Roads was a rendezvous for cargo ships and transports and for the destroyers and cruisers which convoyed them. The work of the Yard was almost always repairs on ships, and was often of a critical emergency nature.

As an Industrial Engineer, aside from the satisfaction of contributing to the maintenance of material for military operations the production work at the Norfolk Navy Yard was a very valuable professional experience in two ways.

First. The Yard was almost entirely a jobbing and repair plant; very little of its work could be standardized and handled by the methods of mass production. Notwithstanding this, the fundamental principles of management were found to apply to its work; and while practically no methods could be adopted from mass production, it was possible to analyze the problems of the Yard by the fundamental principles of management and from them to determine methods which were suitable to the situation in hand.

Second. The civilian employees of the Yard were very strongly unionized, although the Yard is an open shop; and the employees are permitted by orders of the Navy Department to have their Shop Committees and to deal collectively with the management in every grade through such committees. Of course under war conditions labor trouble had to be absolutely avoided. I adopted the plan of always consulting with the Shop Committee concerned about every new step, reaching an agreement with them and outlining the procedure to be followed. I worked always in close touch with the Shop Committees. While they would not agree to everything that I recommended, we did reach agreement continuously to such an extent that it was always possible to keep busy on valuable work; and this work was carried on without conflict, and in fact with the sympathy and cooperation of the union locals. In some cases I was indebted to the higher officers of the unions for aid in persuading the locals to consent to my plans.

I wish to say that close contact with these union workmen during the war gave me a very high respect for them. They were not behind any class of the population in patriotism and willingness to sacrifice their own interest to the interest of the Government. It is of course impossible to generalize from experience in one plant; but, as far as data are available from this experience, they indicate the possibility of dealing with union labor and securing its cooperation in increase of production, on the same lines that I followed at the Norfolk Navy Yard.

WAR INVENTIONS APPLIED TO NATIONAL INDUSTRY

J. H. COLWELL, Primary Examiner,
U. S. Patent Office

In normal times the Patent Office is, to a certain extent, a barometer or index of the industrial activities of the nation, and it is a logical conclusion that under the stress of war conditions the energies, efforts, and thought of the people would, in a degree, be reflected in the applications and specifications filed in the office.

These inventions and improvements disclose many varieties of devices and methods relating directly to war, the purely military, both defensive and offensive, predominating. In addition to the regularly filed specifications constituting a part of the permanent records of the office, letters and papers were daily received, presenting every conceivable form of device, conception and idea designed to accomplish some desired function and result, with requests for advice on the practicability and probable value to the government, and also asking information in some particular field, and how to get a plan before the proper miltiary authorities.

Owing to the widely distributed and more or less inaccurate accounts and reports published in the magazines and the daily press on submarine and U-boat activities, it was but natural that the minds of many were directed in channels towards devising means to meet and combat that menace.

Hundreds of applications relating to U-boats were filed; some of them meritorious and practical, some ordinary, and others crude and of no value in the incomplete form presented towards meeting existing conditions from a practical standpoint. Many amounted to no more than mere conceptions, or ideas, relating to something it was wished to accomplish without setting forth or presenting any concrete structure or means for effecting the solution. Some of these latter may possibly contain valuable suggestions and hints, but the exigencies and conditions of the times precluded any extended experimentation, trials or tests with such doubtful and problematic results. Time was an all important factor and quantity production a necessity.

It is by no means an improbability that in the future, after the country has settled to normal condition and status, that certain of these devices and suggestions, when subjected to careful study, scrutiny and experiment by practical and theoretical experts in the respective lines, may furnish and reveal information to prepare and blaze the way to a practical solution of some present problem in the arts.

It is a curious commentary and phase of human nature that novices start out to initiate and make improvements in mechanisms relating to arts in which they have little or no previous information and knowledge, instead of, as would naturally be supposed, directing their efforts along lines and channels in which they may be more or less familiar.

Numerous suggestions have been submitted relating to submarine hull construction with a view of strengthening and increasing capacity and displacement, improving the propulsion the steering control and the depth regulation, as well as devising safety and escape means in case of the vessel being unable to rise to the surface. These latter take the form in many instances of buoys, which, on being released, rise to the surface, thus serving to locate a sunken vessel, supply fresh air, and furnish communication by means of telephone connections and air tubes to the imprisoned crew.

If in the future the submarine were generally utilized for water transportation ,or salvage purposes, as it is at present to some extent, these devices would be of great importance in serving a most useful and valuable purpose in reducing and obviating unnecessary loss of life and waste of material wealth.

A large field for marine salvage work was created by U-boat destructiveness in sinking a vast amount of tonnage, and it may be that the submarine will become a decided constructive factor in the recovery.

As a defense against submarine torpedo attacks, all sorts of contrivances to protect ships' hulls have been suggested, and submitted to the Patent Office. The most numerous in the early part of the war were in the nature of nets of many varied constructions, including linked plates, endless rotating belts of plating, spars extending laterally from the vessels' sides, and provided with bombs capable of being lowered into the water. It is believed, however, that they failed to be of practical value· Self-prorpelled torpedoes have also been devised to be guided from outriggers to travel a course on each side parallel to that of the ship, and arranged to be controlled and exploded therefrom at will by means of electric connections.

Many forms of so-called unsinkable marine craft have been designed, some taking the form of a great number of small compartments provided with air tanks to render the ship more buoyant; others in providing ordinary ships' compartments with flexible air tight bags arranged to be automatically, or otherwise quickly inflated with gas or air, so that water could be expelled from a damaged compartment; other systems involve a double hull, so that in case the outer shell was damaged by a torpedo or collision, the main hull would remain intact. It is understood that this system has been looked upon with favor by the government and ship men, and many of the suggestions may be of value in the future to practical ship builders and constructors.

The demand for immediate quantity production in marine tonnage brought about a revival in the long dormant art of wooden ship construction. Several systems have been introduced and, with the aid of modern mechanical appliances, ships of considerable size were built in a comparatively short time. A serious objection encoutered is the length of time required to properly season the timber.

Different systems of iron and fabricated construction have been presented, including assembling and uniting the framing, deck beams, and plating by electric welding processes, which in all probability will play an important part in the upkeep of the nation's marine tonnage.

The employment of reinforced concrete in ship building, owing to lower cost, but principally to the facility and rapidity of construction, received a decided impetus. The idea was old, barges and small craft having been built so constructed, yet, it had never been attempted on a larger scale or in sea-going vessels of large displacement. As an example of the practical application of concrete in the construction of sea-going vessels, owing its existence to the exigencies of war conditions, the 5,000 ton steamship Faith, built on the California coast in a period of a little over six weeks is referred to. It is understood that a number of these vessels of considerable displacement, 5000 to 7500 tons, have been built or contemplated, and that their performance has been satisfactory, and a practical success so far as can be judged at the present time. The various plans proposed in this type of vessel follow largely the lines of steel construction with the longitudinal and transverse frame members, bulkhead, etc., constructed of concrete reinforced by various methods. This involved a study of materials with a view of obtaining light, strong, and waterproof stone. It has generally been accomplished by incorporating a naturally occurring light earth, or a manufactured material in the mixture, either in a finely divided form, or as large particles constituting an aggregate for the concrete.

It may be that the designs submitted, efforts expended, and the large amount of information furnished in the patents granted have paved the way for a formidable rival of the steel ship, due to the relative cheapness, and the time saving factor in the construction of concrete ships, which is considerable. About one-eighth to one-tenth of the labor, and that mostly unskilled, is required in building such a vessel, as compared with a steel vessel of equal tonnage.

The importance and the application of heavier than air craft to military purposes is obvious and self evident.

The attention of the country immediately centered on this new form of vehicle, and it was natural that the minds of experts and inventors were directed to improvements in and devising new forms or aeroplanes, as well as to numerous related auxiliary devices, with the result that the Patent Office was flooded with applications bearing on aeronautical devices.

There is believed to be no exageration in asserting that the advance in the development of heavier than air craft made during the past five years would have taken from fifteen to twenty years under normal circumstances. "Necessity is the mother of invention."

In so far as the development of a practical machine is reflected in the Patent Office, no new principle or mode of air sustained flight appears to have been evolved. The aeroplane of the present day is based on the same principle and involves the general structure as first employed by the Wright Brothers in their successful air flight in the first decade of this century. Notwithstanding this, however, there is a wide gap between the air craft of today and that of 1914 as regards the general efficiency, inherent stability, carrying capacity, motive power, controls, radius of action, as well as in various accessories, including instructional and training devices.

The improvements show a general tendency to widen the range of use by anticipating larger load carrying capacity, necessitating increased engine power, and improved motor construction. Different types of modern planes are now equipped with engines ranging up to over 1200 H. P., including multiple engine units with reserve power.

There is no reason to suppose that the limit has been reached, but on the contrary, that air navigation is still in its infancy.

Increased power calls for increased strength in frame construction without too great a sacrifice of lightness, as weight is a vital factor. This brought to the fore forms of bracing, struts, and trussed wing beams. To overcome excessive wind resistance of exposed parts, which causes a useless waste of power and speed, attention was turned to fairing and stream lining all such parts, as struts, spars, engine housings, fuel tanks, and radiator casings, as well as landing carriage frames. As at high speeds comparatively small areas exert by their wind resistance a greater relative detrimental influence, it is even suggested to stream line the guy and brace wires.

To secure increased strength with the necessary lightness, resort is had to hollow metal tubing, but more generally to various forms of laminated wood framing, as embodied in struts, wing beams and ribs, as well as the fuselage and pilot's car itself. With methods devised and means of uniting and arranging the grain of wood laminae, it is possible to construct a wing rib lighter than one of steel of the same strength. Various matreials, as aluminum and other metals and compressed and treated fibrous structure are constantly being devised, as substitutes for linen in the supporting wings and also various substances and compositions commonly termed "dope," for treating the wing surfaces.

The hulls and pontoons of hydro-aeroplanes and flying boats are constantly being icreased in size and strengthened to make them more sea-worthy in withstanding rough water. and the shock of alighting thereon. This has led to the creation of what might be considered a distinct branch in marine ship building, to some extent following the lines of the earlier hydroplane or speed boat. Increased strength necessitates the introduction of longitudinal and transverse hull framing, providing bulkheads for ballast and other compartments analogous to that in ship building with variations to resist special strains resulting from the peculiar demands.

A system of aeroplane construction which is being developed and particularly adapted to large craft, appears on its face, not only interesting, but plausible and practical, provided the location of the weight is not detrimental. Broadly stated, the system comprises a hollow plane merged into the fuselage so that the large trussed wing spars, the engine housings and fuel tanks, as well as the pilot, are enclosed within the lifting surface itself. The centre of the plane between the upper and lower walls is deep, while the wings taper to small depths toward the tips. The entire machine, including the pilot's car, is practically a part of the lifting surface, thereby necessitating comparatively few external wind resisting parts.

Among other devices which are being continually received are detaching means for readily releasing bombs, mail bags and other aritcles, steering devices and automatic controls, wind pressure vanes for automatically regulating the speed, maintaining a constant angle of incidence and preventing machine being pointed dangerously upward to exceed the critical angle and thus cause stalling, with a resulting fatal tail spin.

Knock-down aeroplanes for ready transportation and assembling, telephone and telegraph accessories, and wind fans or mills for driving electric generators, and air and fuel pumps have received considerable attention.

The merits of a heavier than air craft capable of hovering in the air, or stopping in flight, and also of descending and rising vertically have been fully appreciated both for military and other purposes. The advantages of such a machine are obvious; among them is the necessity of only a limited or small area or ground space for landing and launching. Numbers of machines designed to possess these qualifications have appeared, the most common type being the helicopter or horizontally rotating screw propeller for exerting vertical thrust. Some of these have no lifting plane, relying solely on the helicopter thrust, while others propose to use the helicopter in conjunction with the ordinary aeroplane and so to arrange the power transmission that the tractor or pusher propellers can be cut out and power applied to the helicopter, or both operated simultaneously.

Although it appears that, as yet, no practical and successful machine of the above type has been evolved, it is by no means improbable that this problem will be solved in the near future, in view of what has been accomplished and the great strides in development along these lines by keen-minded men of mechanical experience.

In view of the constantly increasing altitudes being reached in air navigation, numerous systems are being developed for obviating the ill effects of the highly rarefied atmosphere, both on the pilot and in the functioning of the motor. These comprise various arangements for compressing air, including wind fans, or motors otherwise operated. Some utilize the exhaust of the main engines for driving a turbo-compresser. By this means, a constant supply of air at uniform pressure is received, which is automatically regulated in accordance with elevation.

In hydraulic and fluid pressure apparatus, the general trend during the past three years appears in details of invention in previously known types.

Hydraulic motors in variable power forging presses have been designed and improved to secure more complete control of high and low pressures, economy of high pressure fluid, and simplicity of the valve mechanism employed for those purposes.

In fluid motors for hydraulic turbines, an improvement of more original character, which is believed to have considerable importance, consists in so arranging the draft tube through which the water discharged from the turbine flows to the tail race that a large part of the energy usually remaining in that water is regained by means of a suction effect upon the water which is passing through the turbine. By the use of this improvement, natural low heads, which would not be otherwise profitable, can be made available; but its utility is not confined to such cases.

In steam turbines of general application, the type having reversly rotating disks carrying blades in position to revolve in adjacent circles in a space through which the steam flows radially from centre to periphery has been particularly developed.

In elastic fluid turbines, especially intended for aeroplanes, certain inventions which utilize the gas, that may be derived from a fuel burned in, and exhausted from, the main motor to drive an auxiliary mechanism, such as a fan to cool the motor, are igenious and of practical value. In some instances, the main motor is fed with fuel at a rate to correspond with the elevation of the aeroplane.

To fluid current motors, including impellers for driving vehicles, among others aeroplanes, inventors have been and are paying considerable attention. Special efforts have been directed to the form, material and mode of construction of the blades of screw impellers.

In air and gas pumps, recent activity has been toward the automatic control of high duty compressors. Particular points which may be mentioned are devices for speed governing electric motors, driving compressors, and the improvement of thin elastic metal valves and co-operating parts for scuh service.

A pioneer improvement of seeming high merit and real practical value within its field has been developed for producing very high vacuum by means of a jet of vapor, say vapor of mercury, the characteristic function in which is the prevention of any flow of molecules of vapor toward the space to be evacuated.

In pumps, special attention has been directed to improvements in the valve mechanism for controlling the flow of actuating fluid in pumps for drilled wells of the type wherein compressed air acts directly upon the liquid to be pumped, and to improvements in associated devices for automatically controlling the action of such pumps.

In the art of photography, there has been a marked development, including cameras especially adapted for taking photographs from air craft, and in methods of utilizing such photographs in map making and surveying; meter reading cameras for making photographic records of the readings of gas, electric and other meters; color photography, including photo-mechanical color reproduction processes; printing machines for printing photographs, and especially for printing moving picture positive films from moving picture negatives; and range focusing cameras, consisting of range finding devices interconnected with the focusing mechanism to facilitate focusing.

In metallurgy and metal treatment, the trend of activity has been to reproduction of new alloys and the treatment of steel compositions to enhance various chemical and physical properties. Among the various metal compositions, alloy steels are most numerous, and the number of applications involving the employment in alloys of rare and refractory metals have been steadily increasing. Heat treatment of iron and steel materials is an art which seems to be developing and apparently becoming of great importance.

The art of electric welding is constantly advancing and the developments of the past few years have apparerntly been so important that the art may be almost designated as "new art." In the electric furnace art, both apparatus and processes have received great attention, and the applications of the electric furnace to steel making and alloy manufacture comprise an important part of this activity.

Numerous applications have been filed for patents on gas masks and many of the improvements made therein are applicable for use in mines and other places where poisonous and noxious gases are likely to be found.

Of most significance in the chemical arts, the following have seen the greatest activity and offer promise in their application to normal peace industries:

Chlorination and nitration processes of organic substances in the preparation of nitro- and chlor- derivatives of value not only in explosives, but also in dye manufacture; such chlorinated and nitrated products find extended use as solvents and as starting points in organic syntheses. The need of organic solvents, etc., such as alcohol, acetone, etc., has given added impetus to the production of these materials by fermentation and saponification, the latter process often accompanying an initial chlorination step, further, catalytic oxidation has been applied to these various materials to produce valuable substances such as ketones and organic acids, the development being both in the method of treatment and the materials treated.

The manufacture of nitrogen compounds by fixation of atmospheric nitrogen became of the most vital importance during the war, and many processes were devised both for the production of intermediate nitrogen compounds in this way and for their conversion into explosives. During the past year, a large number of patents have appeared, many of which were withheld from publication while the war was in progress, dealing with various phases of this subject. Although the need for vast quantities of explosives has passed, nitrogen compounds are as necessary for soils as for shells, and it appears that many of the fixation processes may be economically applied to the production of fertilizers. Perhaps the process which furnishes the largest amount of atmospheric nitrogen in fixed and available form is the cyanamid process. This consists in brief in fusing a mixture of lime and carbon in an electric furnace to form calcium carbid, treating the carbid with nitrogen to form calcium cyanamid, and subjecting this to the action of water at high temperature and under pressure to free ammonia. The ammonia so obtained is oxidized by passing it with air over a catalytic substance producing nitrogen oxids. These yield nitric acid by absorption in water.

Ammonia and nitric acid are similarly produced from cyamids, nitrids and other salts containing fixed atmospheric nitrogen. A number of patents have also been recently issued relating to the direct synthesis of nitrogen and hydrogen to form ammonia. Ammonia produced in these ways may be neutralized with sulfuric acid, yielding ammonium sulfate, one of the most valuable fertilizers. Where nitric acid is produced by oxidation of ammonia, it may be converted into useful agricultural form by treatment with lime or other basic subsances to form nitrates. It is asserted that on a large scale of production, fertilizers so produced can compete in price with sodium nitrate from the Chile nitrate beds, the former principal source of supply. The only other important source of nitrogen products, aside from the fixation of atmospheric nitrogen and the Chile supply, is the recovery of ammonia from the distillation gases of coal. In this country, a large number of coke ovens are not provided with recovery works. This waste is gradually being eliminated, however, and a number of recent patents cover improvements in the technique of recovering ammonia from coal gases as ammonium sulfate.

In the manufacture of refractories for steel furnaces and the like, magnesite and dolomitic limestone have been used in an attempt to make refractories equal to those formerly made from the Austrian magnesite. A study of the proper relations of flux to the refractory has developed improvements over the prior art.

In devising compositions for special glasses and lenses to be used for transmitting and absorbing various kinds of light rays, especially the ultra-violet and infra-red, metals hitherto not used in this art have been dissolved in the glass batches, either in elemental or combined condition.

The recovery of potash from feld-spar by fusion or learching and from flue dust from cement kilns by electrical precipitation or absorption, has been seriously studied by chemists since the shutting off of the German potash fields.

Activity in the art of fire extinguishing compositions has been largely in the field of organic extinguishing liquids. The problem in both organic and inorganic chemical preparations has been to obtain liquids of very low freezing points, while retaining extinguishing properties of the highest degree. The halogen substitution products of certain hydrocarbons are uninflammable and have been known for several years to be good fire extinguishers, the most common and least expensive being carbon tetrachloride, but this freezes at -3°F. Several organic compounds, both solid and liquid, have been patented in combination with carbon tetrachloride for the purpose of lowering the freezing point. Another important direction, although less extensively followed, has been toward improvement of foam producing methods, combined and coacting with extinguishing liquids.

In the art of fireproofing materials, cloth has been the special material to which attention has been directed. Coatings for aeroplane wings, having a cellulose ester base and fireproofing ingredients have been recently patented.

Improvements have been made in processes for precipitating exchange silicates or filter masses, which soften water by double decomposition reactions. The aim has been to obtain silicates having good physical characteristics such as subdivision and hardness, as well as chemical efficiency.

In varnish making, cumarone and indent resins, found in solvent naphtha (165°-175°C.) are polymerized by acid, heat, or dehydrating treatment, producing resinous substances soluble in certain organic solvents.

Considerable attention has been directed to devices and systems used in the industries for purifying water and separating by-products, many being utilized in mining and metallurgy.

In the electric art, in some lines tremendous advance has been made during the past three years. One aspect is especially noteworthy, viz., the rapid breaking down of the line between the three arts of telegraphy, telephony and radio communication, and the development of a signaling are common to the three, making use of elements heretofore generally regarded as more or less characteristic of one or the other of these arts.

In the radio art, specifically regarded, improvements have been made along several lines. The antenna element and the concept of its mode of functioning have been studied, and especial attention given to large aerial constructions and to the more extended use of the loop form. In connection with the latter, particularly, underground and underwater radio systems have been developed and systems for signaling to submarines. The important question of static and other interference has produced much activity, giving rise to applications of the loop antenna and to various special arrangements of extended aerials, and changes both in receivers and transmitters. The small loop or coil has been found useful in further development in directive transmission, and in the aeroplane radio compass.

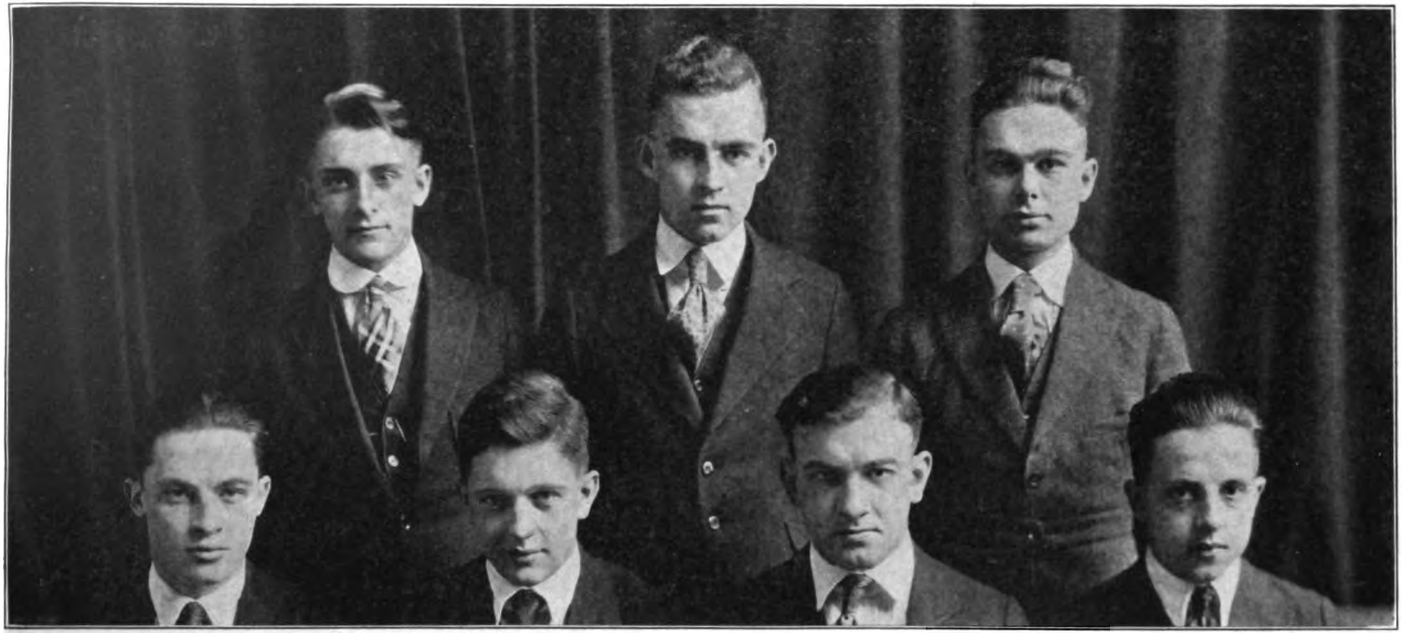
In the case of so-called high power stations, i. e., of the Poulson arc type, the controller has been greatly improved, and considerable use has been made of audio-frequency in telegraphy, telephony and radio torpedo control at short distances.

Vacuum tube generators and amplitude control, or "modulation," of the generated oscillations have been constantly improved; and their easy adaptation to wire telephony or to composited systems has opened up a large field of improvement, especially in long distance multiplex telephony, so that now what was once a single communication line, telegraph or telephone, is one providing several "channels" for simultaneous communication.

This has naturally led to many improvements in balancing networks, including filters, loading coils, etc., and in the amplifier or relay elements. This last feature has been attended by a great development in the so-called vacuum tube relay and the repeaters, of which it generally forms a part. Balancing means are automatically selected and connected in repeater systems and for use in composite and phantom circuits. Multi-stage amplifiers are now practicable. Developments in the vacuum tube have been along the lines of electrode arrangement and composition involving the new use of many rare metals, and salts of various gas contents involving rare gases, of the cooling of the tubes, and of circuit connections therewith.

In telephony, strictly regarded, the tremendous advance of automatic development has continued, many improvements being directed toward greater applicability of automatic switching, this automatic type being made to furnish all the service of a manual system. Much attention has been given the private automatic exchange, also to simplex and phantom adaptations, and refinement and variation in switch structure itself.

It is firmly believed that this vast store of more or less valuable information and knowledge called into existence under stress of war conditions can and will have an important bearing on the great constructive work now confronting the nation and exert a stimulating influence on the peaceful arts.



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The Purdue Engineering Review

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SCHOOL OF CHEMICAL ENGINEERING

This school still continues to grow and has outstripped its present facilities.

Additional training in Physical Metallurgy is being offered to specially chosen members of the senior class. It is expected to expand this important line of work as facilities permit.

The Chemistry Department has been strengthened by the addition of Dr. M. G. Mellon, in Quantitative Analysis.

Research work is in progress on:—The study of chemical reaction in the high frequency corona, especially the formation of ozone and nitric acid from air.

The study of chemical reactions in direct current corona, especially the laws governing the formation of ozone from oxygen, under carefully regulated conditions. This has a very important bearing on the question of making ozone more efficiently.

The study of the role of ultra-violet light in the chemical reactions of the corona with the aid of a large apectroscope.

The action of ozone on the bad odors that may occur for ventilation purposed. With the use of ozone it is possible to recirculate the air instead of discarding it with great saving in coal.

The efficiency of the oxidation of carbon monoxide in the silent discharge will shortly be published.

Slag inclusions in iron and steel.

Technical development of a commercial process.

SCHOOL OF CIVIL ENGINEERING

The School of Civil Engineering resumed its normal operation in September with Professors Smith, Knapp and Martin returned from service with the United States Army.

February 1st, Professor Martin, in charge of Highway Engineering, resigned to take a position with the Barrett Company, and the instruction of Highway Engineering was put in charge of Professor Albright.

Messrs. J. F. Parmer, C. E., '16, and L. R. Croy, C. E., '17, were appointed instructors in Civil Engineering.

Professor Hatt returned after a six months' absence, during which time he was partly in the service of the Committee on Education and Special Training of the War Department.

Professor H. J. Kesner of the Structural Department was employed during the summer of 1919 in developing standards and specifications of bridge design for the Indiana State Highway Commission.

Professor Wiley was in charge of the design of sewer disposal plant for the city of Detroit during the summer of 1919. He has prepared a bulletin for the Engineering Experiment Station on "Sewage Disposal for Small Towns and Farm Communities."

TOPOGRAPHICAL DEPARTMENT

The summer camp was held at Pentwater, Mich., for six weeks in 1919. In 1920 the camp will be located at Glen Lake, Mich., where about one hundred sophomores will be in charge of Professors Hatt, Lommel, Knapp. Glen Lake is about 100 miles north of Pentwater and offers excellent facilities for varied topography, and the camp site will be removed from the attractions of a small town. The camp has been lengthened to eight weeks to provide for the instruction in Higher Surveying, which has been omitted from the junior year in order to provide for increased instruction in Highway Engineering.

An exchange of old instruments has been effected so that the surveying equipment in the School now contains mainly modern equipment.

This year Topographical Military Surveying has been taught to all sophomores of the University under the direction of Professor Knapp, who had wide experience in this work while in the service in France.

HIGHWAY ENGINEERING

The sixth annual Road School was held in cooperation with the Highway Superintendents' Association, County Surveyors' Association and State Highway Commission on January 27, 28 and 29. The attendance, which was the largest in the history of the Road School, reached a total of 242. Officials from 58 counties were present. The County Highway Superintendents' Association voted to hold its future meetings at Purdue University.

The School now offers continuous instruction for two years in Highway Engineering, beginning with the first semester of the junior year.

HYDRAULIC LABORATORY

Research on the discharge of sewage-sprinkler nozzles has been completed and published in a bulletin of the Engineering Experiment Station. A very promising research in the co-efficients of discharge of parabolic weirs is under way.

Equipment has been added as follows:

One Price Current Meter with complete auxiliary apparatus.

One 300 GPM centrifugal pump to operate against a total head of 50 pounds per square inch.

The Engineering Experiment Station has provided a permanent research assistant for the Hydraulic Laboratory.

LABORATORY FOR TESTING MATERIALS

The long series of experiments on the concrete making properties of Indiana sands and gravels for the Indiana Sand and Gravel Producers' Association was completed this year, and the report is now being prepared.

Progress is being made upon the survey of road materials in the State of Indiana. This will be of great value to the State Highway Commission and Contractors of the State looking for supplies of available materials.

Standard tests of materials have also been made for the Indiana Highway Commission upon materials intended for use in government roads.

Research is underway upon standard tests for the abrasive resistance of gravels and for the standardization of a testing machine, which will subject concretes to a test for wearing qualities. From this latter research it is expected that specifications may be drawn to control the use of aggregates in concrete for roads.

The plans for the large two million pounds testing machine are now complete and it is hoped that they will be sent out for bids in the next few weeks.

The floor plans have been completed and tentative drawings made for a new testing laboratory, which is expected to be erected in the rear of the Civil Engineering Building whenever the conditions of the building industry will permit a reasonably economic construction.

Apparatus for testing bituminous materials has been added to the Testing Laboratory which is now in direct charge of Mr. R. B. Crepps.

GENERAL

The School of Civil Engineering has been conducting a survey of the occupations and salaries of the Alumni of the School with a view to occupational guidance and fitting the curriculum to the modern activities of engineering. The survey permits a determination of the most promising fields of enginering practice. A card catalogue is being built up which will permit the intelligent recommendation for outstanding men for exceptional opportunities. The School notes with satisfaction the increasing number of Alumni who are being advanced to executive and administrative positions with large compensations. The curriculum in the past several years has been modified so as to permit a broader training without the sacrifice of thoroughness in technique.

SCHOOL OF ELECTRICAL ENGINEERING

Research.—Research in connection with the fixation of atmospheric nitrogen has been carried on continuously for three years in the School of Electrical Engineering. During the past year, this work has been done under the auspices of the Engineering Experiment Station, although several members of the staff of the School of Electrical Engineering have been interested and active in the work. Dr. Anderegg of the Department of Chemistry has also been of great assistance. The first progress report upon this research problem was presented by Professor C. Francis Harding and Mr. K. B. McEachron at the Boston meeting of the American Institute of Electrical Engineers and the American Electro-Chemical Society, held on April 9th, and was published in the April Journal of the A. I. E. E.

Mr. H. C. Thuerk, a graduate student, has done some very valuable research work upon the affect of power factor and load factor upon central station rates. An abstract of this work appeared in the Electrical World, February 21st, and has also been discussed with much interest by central station managers in meetings of the Worcester, Mass., and LaFayette-Indianapolis Sections of fthe A. I. E. E.

Mr. C. W. Piper has completed a set of very comprehensive tests on electric and gas ranges which has been published as a bulletin of the Engineering Experiment Station.

Prof. D. D. Ewing and Mr. G. C. Blalock have completed an investigation upon electric pumping systems for municipal water-power plants, the results of which will be published in a circular of the Engineering Experiment Station in the near future.*

High Voltage Laboratory.—The new 600,000 volt laboratory has been completed during the past year and consists of two 300,000 volt condenser terminal transformers controlled by means of hand operated motor driven drum controller and auxiliary variable voltage transformer. This equipment, which was furnished by the Westinghouse Electric & Manufacturing Company, has given very satisfactory results. It is installed in an extension of the Electrical Building north of the original high voltage laboratory.

It is expected that research work in connection with insulating materials at high voltages and the corona losses on transmission lines will be undertaken with this equipment in the near future. At present tests are being made upon the equipment, and the effect of the control apparatus upon the wave form of the voltage in the secondary circuit is being investigated.

Personnel.—Captain L. D. Rowell has returned to the staff of the School of Electrical Engineering from war service in the Engineer Corps, Washington, D. C.

Mr. C. W. Piper has left the staff to enter upon commercial engineering work in Cincinnati. Aside from these changes, the personnel of the organization is the same as before the war, although during the period of the war it was very greatly augmented to provide for a large amount of extra instruction, carried on with the enlisted men who were assigned to the University in addition to the regular students.

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*Professor R. V. Achatz has made an extensive investigation upon the effects of various preservatives upon the life of telephone poles in the soil of Indiana. This investigation is now in the hands of the printer.

SCHOOL OF MECHANICAL ENGINEERING

The school of Mechanical Engineering as a separate school was authorized by the trustees in 1884 and the following year the first student in M. E., was graduated. From that time on this department has been doing efficient work and for twenty years was in fact the leading school in engineering in the west. Since then 1,292 Bachelor degrees and 360 Advanced degrees have been conferred. Last year and again this year the School of Mechanical Engineering is the largest of all the Schools of Purdue University.

The construction of the Mechanical Engineering building was made possible in 1892 by the gift of Amos Heavilon and other friends of the University living in Tippecanoe County. The new engineering building with its shops and laboratories was dedicated January 21, 1894. Two days after, the main building, laboratoes and part of the shop wings were completely destroyed by fire. Within two years, the present building was rebuilt on the same plans as the one burned. The locomotive which was in this fire when rebuilt was placed in the present locomotive laboratory. In June of this year fifteen degrees were given in Mechanical Engineering.

In the year 1911 the buildings of the department of Practical Mechanics were completed and the wings ot the present Mechanical building were made available for new laboratories.

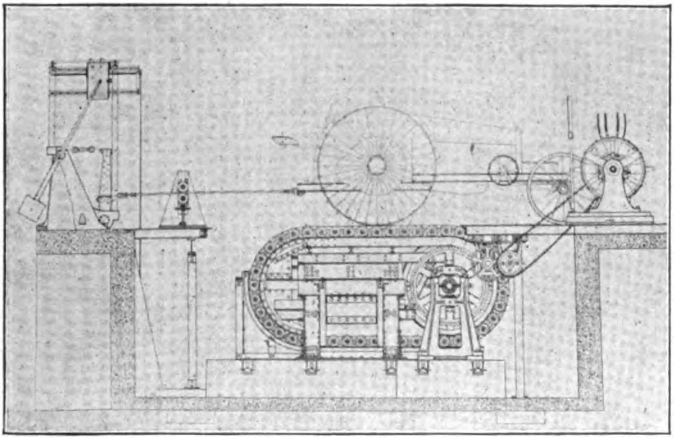
The School of Mechanical Engineering is noted for its fine laboratories in Steam, Gas, Automobile, Tractor Testing and Railway work. For twenty years this school has had charge of the Master Car Builders' equipment of air brake racks, brake shoe machine and drop testing machine. This department has been a pioneer in railway work and automobile testing. The new Tractor Testing Laboratory has been completed and the standardization of Farm Tractors is now in progress. The machine for determining the effect of flat spots on car wheels is the only machine of its kind in existence. The belt testing machine is acknowledged by experts to be the finest in the country. The completeness of gas laboratory equipment with its two kinds of gas producers, and internal combustion motors of many types, the Diehl Dynamometer for special, is a source of surprise and favorable comment from visiting engineers. Plans are now being prepared for new laboratories in heating and ventilating and refrigeration where special lines of research may be carried on in these important branches of engineering.

Students in Mechanical Engineering may specialize in the following courses: Steam Engineering, Gas Engineering, Railway Engineering, Heating and Ventilating and Industrial Management. The graduates are well prepared by their broad course in Engineering and soon are found in responsible well-paying positions.

THE ENGINEERING EXPERIMENT STATION

Experimental work on various engineering problems has been carried on at the University for many years.

Scientific investigations of much practical importance have been made and the results published as papers before technical societies and as articles in engineering periodicals.

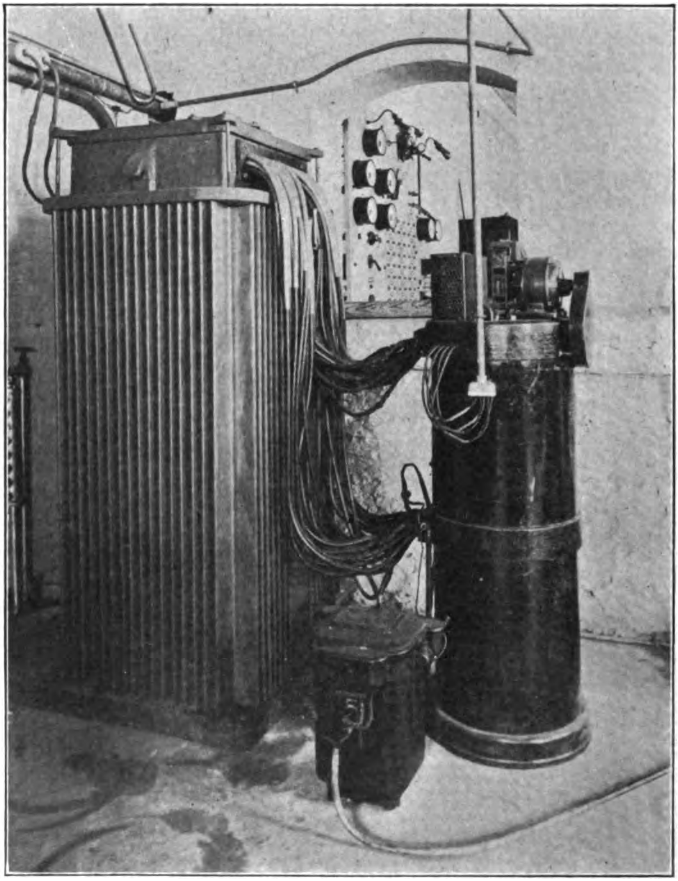


Experiments on the Purdue locomotive with high steam pressure and with superheatted steam, tests on railway material in the shape of rails, car wheels, side frames, brake shoes and brake beams, and investigations of various building materials, wood, steel, brick and concrete, all these were done before the Experiment Station was even mentioned.

The station is not a new thing, it is a more modern and efficient development of the work already here.

It has enabled the engineering schools to segregate the experimental work, to provide a regular staff and special apparatus for this work.

The Trustees authorized the establishment of the Station in the spring of 1917 and in August of that year, the first circular was sent out in the form of a prospectus.



The Station is organized with a board of management consisting of the dean, who acts as director, and the heads of the four schools involved. The staff consists of chiefs, usually members of the faculty, research assistants and employees.

Beginning with one assistant, the staff now consists of two chiefs, six assistants, and three employees.

The publications already completed are as follows:

Circular—"Lightning Protection." C. F. Harding.
Bulletin—"Flow of Water Through One and One-half Inch Pipe and Valves." F. W. Greve.
Bulletin—"Electric Ranges." C. W. Piper.
Bulletin—"Coefficients of Discharge of Sewage Sprinkler Nozzles." F. W. Greve.
Bulletin—"Electrically Driven Pumps in Small Water Works'.' D. D. Ewing.
Bulletin—"The Mixture Requirements of Internal Combustion Engines." O. C. Berry.
Circular—"Preservative Treatment of Wood Poles." R. V. Achatz.

The more important investigations which are now well under way are the testing and classification of the sands and gravels of the State, the fixation of atmospheric nitrogen and the testing of farm tractors. The new high tension laboratory used in the nitrogen investigation is one of the best equipped in this country, while the tractor testing plant has no counterpart.

Several new problems are being considered as available projects. Practically all of the work undertaken by the Station is of such a character as to be of direct benefit to the industries of the State.

The Station stands ready by advice, by consultation and by experiment to assist the manufacturers and the public utilities of the commonwealth and to help in solving the industrial problems which are called to its attention.

Department of Practical Mechanics

Processes of manufacture have undergone a revolutionary change in the last few years. The day of the hand-craft article has departed and that of the machine-made product has arrived bringing with it a degree of refinement in machine finish and size heretofore considered as impossible as the most extravagant tales of Munchausen. We find ourselves in an age of machinery and rapid production and confronted by a demand from the shops and manufacturing plants of the country for skilled operators, designers, technical experts and production managers. Here is a quartet of responsibilities that is well worth our serious consideation. The first group in the quatet comprises by far the greatest number of men but the remaining groups are much more difficult to fill. A skilled machine operator may be developed for any given process without a knowledge of any of the co-ordinating processes. Such a man acquires his art in a comparatively short time and becomes a vital part of the machine he operates but is not prepared to advise intelligently upon lines other than his specialization. The Designer on the other hand must have a thorough working knowledge of shop processes and manipulation, and in addition must be able to work out theoretical conceptions in terms of actual machines. This man is a mechanic and a technician and requires years of experience to obtain proficiency. The Technical Expert is the engineer and research man for the establishment. He must be both practical and theoretical man and in connection with the designer is reponsible for the scientific development of the manufactured product. The Production Manager must be a master of shop processes and a thorough student of human nature. His effectiveness in the work is determined by a wide experience and fitting native qualifications.

Under the old order of things these directing minds in the plants were recruited from the ranks through the apprenticeship system. However, with the gradual decadence of the apprenticeship system the manufacturing world began looking toward the technical schools of the country to supply this ned. So far the technical schools have been giving large numbers of graduates to other lines of engineering but few to the shop and manufacturing plants as experts. This condition has prevailed partly because competitive manufacturing has not until recently been so keen and did not demand the more scientific and refined processes in production. Another reason is that the average technical school shop equipment has been so limited in machines and appliances and the time allowed for such work has been so reduced that training much beyond the elementary shop processes is precluded. Educators throughout the country have been honestly endeavoring to develop engineers with inspirational, constructive and initiatie powers, but in many cases upon a basis so theoretical and ideal as to obscure the real objective. That is to say—if the greatest results are to be obtained in an educational way the student should be thoroughly "shop-broke" and should know the relation of the shop and the shop product to the industrial world before entering upon the more advanced theoretical subjects. A course in manual training is good as far as it goes—but it does not go far enough—neither is it good policy to attempt the engineering features of shop instruction without having had a fair training in the manual work. To do this would be comparable with the mother who attempts to force the development of her child with a diet of beefsteak when milk is the only died it can digest.

The Practical Mechanics Department of Purdue has always studied to meet the current needs of the engineering field without being spectacular or radical. The courses of study are always under process of revision but these changes never become drastic. At the present time several new courses (substitutes for and given in parallel with the regular courses) have been added for students entering with satisfactory manual training experience. These courses omit the elementary exercise work and emphasize the scientific and engineering features of production. From the importance given to manual training in the high schools of the country these substitute courses should gradually increase in importance. Considering the extent and scope of Purdue's shop and drawing room facilities, which it is safe to say are second to none in the country, and the fact that the courses are planned and given by men who are at the same time technical men and skilled tradesman, it is believed the department is justified in looking forward to a closer union with the commercial field of the manufacturer.

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The Purdue ENGINEERING REVIEW

PURDUE UNIVERSITY
1921

No. 16

MAY, 1921

Purdue University

LaFayette, Indiana

A COLLEGIATE institution founded upon an act of Congress of July 2, 1862, named in honor of its benefactor, John Purdue, a citizen of LaFayette; aided by numerous private and public gifts; maintained by appropriations from the State of Indiana and the United States; offers instruction in undergraduate and graduate courses in Science, Agriculture, Engineering and Pharmacy.

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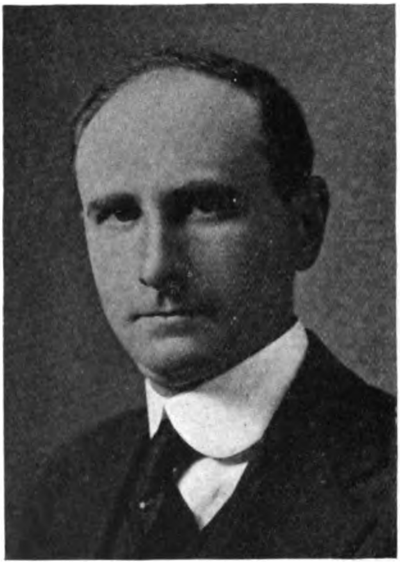


A. A. POTTER
Dean of Engineering

PURDUE
ENGINEERING REVIEW

No. 16 PURDUE UNIVERSITY 1920-21

THE ENGINEER IN INDUSTRY

By Louis Ruthenberg, Ex-'08,
Superintendent Delco Co., Dayton, Ohio.

Before we hit a few high spots in the very broad subject "The Engineer in Industry," matters might be clarified if we can arrive at a mutually acceptable definition of an engineer.

I like to think of an engineer as "one who reduces the developments of science into tangible means for advancing civilization." I think you will agree that this definition is sufficiently broad. Perhaps some of you will say that it is too idealistic. But in these days of great specialization, I believe it is very important that, no matter how narrowly our individual activities may be specified, we should retain a broad and, if you please, an idealistic conception of the engineer.

The engineer is being accepted by both the industrial and technical worlds into fields of ever increasing breadth and this process will continue, probably, only as the engineer himself conceives engineering in the broadest and most ideal sense.

Because of the tendency to specialize, we have come to draw certain lines between various branches of engineering. As students we have lines drawn between us, as mechanical, electrical, civil, chemical engineers, and so on. **Let us recognize that the student or engineer who would go far, is he who will make the most successful application of those fundamental laws which apply in common to all branches of engineering and which are applicable very directly to the problems of commerce and industry.**

The ablest engineers that I know have forgotten that lines of any description exist between the various phases of engineering and move about equally at home in one field or the other.

Such men whom we regard today as super-engineers, have not so much mastered the details of the various branches of engineering as they have recognized the fundamental fact that all branches of engineering are, after all, pretty much the same thing; that they have simply grown up like different nationalities of the same race, speaking somewhat different dialects. These men have found the common tongue.

Mechanical engineers rig up most complicated "dog leg" contrivances to acomplish results that the simplest electrical relay would effect at a fraction of the cost. Electrical engineers string together numerous magnets to achieve that which could be better accomplished pneumatically or hydraulically.

Engineering training must not be permitted to tie men too closely to tradition and, by so binding them, destroy their imagination and vision. It is a rare mind that is neither too free of traditional guidance nor too much restricted by tradition.

Charles P. Steinmetz is credited with this statement: "Wise men will gather about the table and prove conclusively that a thing cannot be done; at the same time an untaught genius, too ignorant to know that the thing cannot be done, will go ahead and do it." This is simply Dr. Steinmetz's way of pointing out the danger of traditional restraint. To arrive at a clearer conception of the effect of traditional restraint, suppose we spend a few minutes taking an imaginary trip around the world.

Starting with China, we find a nation with almost unlimited natural resources, which has not made perceptible progress for hundreds of years, simply because the national philosophy teaches them to worship that which has been done in the past. They are restrained by tradition to a degree which makes them move backward rather than forward.

Jumping into England we find a better balance between traditional restraint and progressiveness. As Americans, most of us feel that England is too much bound by tradition. In England we find a current expression, "It isn't done," which simply means that it isn't done because custom or habit or tradition forbids its being done. We are not interested at this time in deciding whether or not England has found the logical compromise, but simply in observing the effect of traditional restraint.

As we come across the Atlantic and observe the effect of traditional restraint in the New England States, we find that tradition restrains people less than in old England, but some of us in the middle west feel that even New England lacks progressiveness because of the conservative spirit, which is simply another expression for traditional restraint.

Here in the middle west of the United States, most of us are willing to admit that we have found the logical compromise, that while we are guided by tradition, we are not so restrained as not to be logically progressive.

As we move out into what was but yesterday the frontier of our civilization, down to the Pacific Coat, less and less restraint is found, as a result of tradition. But please observe that the **guidance of tradition** has had much to do with the successful pushing forward of our frontier.

Jumping from the Pacific Coast to Japan, we find a most interesting condition brought about very largely by reaction against a system which has until quite recently held a people in traditional restraint through the centuries. Just now, in many respects, we find the Japanese people ultra-progressive. We find them making what we regard as very foolish and very serious mistakes. Most of these apparent mistakes are traceable, I believe, to the sharp reaction against the old philosophy under which tradition was worshipped to a degree which finds a close parallel in the present situation in China.

Engineers vary in their progressiveness almost as much as the peoples we have just discussed. You are all more or less familiar with the engineer who might be called the Chinese type, who moves backward rather than forward because of his respect for certain traditions. You know the type of engineer who might be called the American middle-west type—guided by tradition, but not over-restrained. You know the Pacific Coast type, who has so little respect for tradition that he is always accomplishing something which, according to tradition, simply could not be done. And then, there is the Japanese type, reacting against a period during which he was restrained by tradition and reaching the extreme where he tries to accomplish things absolutely without traditional guidance simply because of that reaction.

The facts and formulae which we have impressed upon us as engineering students must not be worshipped, nor even highly regarded, as things of first importance within themselves. Sanely valued, facts and formulae become simply the tools by means of which an engineer attacks the problems he may encounter regardless of whether these problems fall under those arbitrary classifications of mechanical, electrical, civil, chemical, industrial engineering or merely under the broad classification of business problems.

In a properly operated factory, we rarely shape our production to meet the limitations of our tools, but rather keep our tool equipment sufficiently flexible to meet the varying production problems as they confront us. So we may logically conclude that it would be very unwise if we should regard these mental tools—facts and formulae—as things so inflexible that our problems must be made to conform with our mental tool equipment.

I believe that it is fair to state that most worthwhile human accomplishments are the result of three more or less distinct operations:

First—Analysis
Second—Planning
Third—Execution

If an engineer's training is to be of any great value to him it must enable him to distinguish these functions and it will develop within him most particularly the power of analysis.

These characteristics are ones which we often find woefully lacking in the practical, shop-trained man. His training over-emphasizes the importance of the last operation, execution, and very often, without any clear cut analysis of his problem or planning its solution, he will jump into the middle of the **actual doing** of the job, with the result that he often fails to accomplish the desired result and frequently (having analysis and planning thrust upon him in some muddled sense by his failure of the first or intermediate attempt) will succeed in accomplishing the result only after several unsuccessful attempts.

Now, so far, we have indulged in some very fine generalities. It has been intimated that fundamental engineering laws apply directly to many of the problems of industry and that, therefore, engineering treatment is applicable. It is beautifully simple and easy to indulge in these generalities, but I imagine that some of you would like to "call my bluff" about this time and ask me to get down to specific cases.

All of us have been taught that "every force has an equal and oppositely directed reaction." As I recall it, this statement was encountered very early in the study of Professor Ferry's Elementary Dynamics. Now, let us examine how this very elementary law applies to some of the problems of industry.

Just a few years ago, under a political administration that may be regarded as either radical or progressive, depending upon one's political point of view, the Adamson law was passed which guaranteed to railroad **labor** certain rights and privileges.

The "equal and oppositely directed reaction" came about under a reactionary or conservative congress (again depending upon one's political sympathies). The Esch-Cummins bill became a law. This law guaranteed to railroad **capital** certain rights and privileges. I believe that these two laws, in connection with the surrounding conditions, represent a very beautiful study of the law of action and reaction as applied to labor and economics.

Another illustration: If I should take two maps of the United States and upon one of them indicate those areas in which there have been labor trouble during the past five years and upon the other indicate those areas in which management is now retaliating by sharp reductions in wages and by actively fighting the closed shop, I could superpose the two maps and find that the two areas were almost exactly coincident. So much for the application of that particular principle.

You are, of course, all familiar with the characteristic curve that may be plotted for the amplitude of vibration of a spring returning from a position of strain to normal or the characteristic curve representing the discharge of an electrical condenser. You might plot a very similar curve which would represent the present and forecast the future economic and social situation of the whole world. The economic and social fabric of the entire world has lately been placed under tremendous strain and so we shall find conditions vibrating from subnormal to abnormal until they are affected by other forces or find their normal status. The present industrial depression in this country could be located with comparative accuracy at some point on this curve.

You all know that by finding the initial characteristics of a curve it is often possible to project the balance of the curve with considerable accuracy. Some of you may be familiar with the methods used by the Babson Statistical organization, which very successfully applies exactly this method to forecasting commercial and industrial conditions. Incidentally, you cannot read any of the Babson literature without encountering within the first few paragraphs an expression of a law of action and reaction.

Engineering methods have been applied to the control of physical materials in our plants for a long time. As a matter of course we analyze the requirements of a given part and as a result of such analysis, specify within commercial limits the chemical or physical characteristics of acceptable materials. Then we specify within exact limits the treatment such raw material is to receive within our plant. If we have analyzed requirements clearly and planned our specification wisely we can be certain of satisfactory results, providing, of course, that satisfactory means exist and are used for checking our specifications.

But regardless of the relative importance of the human side of industry, we have only recently begun to learn how to apply engineering methods of analysis and planning to the control of that human factor about which all other factors may be said to revolve. As engineers we know a great deal more about the habits and tendencies of nickel steels and bearing metals than we know about the habits and tendencies of the human animal.

The difference between the two problems—physical and human—might, from an engineering point of view, be regarded as a study in relative variables. In laying down chemical specifications for the more complicated alloy steels, we are interested in controlling five or six or seven variables—for example, nickel, chromium, carbon, manganese, sulphur and phosphorus. It is a comparatively simple matter to study the relation and inter-relation of these.

In laying down human specifications to fill the simplest kind of a job, who can say how many variables we must consider? What do we know about the relation and inter-relation of such variables?

To be perfectly truthful, we don't know much about such things, but the significant fact is that we are starting to learn.

In every-day industry we are beginning to put into definite terms our analysis of the job. And we are beginning to put down specifications for the human material necessary to meet the job's requirements. We specify certain educational treatment for that raw material. Our means for checking specifications are still very elementary and crude, but crude as they now are, we are trying to find out more about trade tests, mental alertness tests, and the like; about where and how they actually fit into the scheme of things. We are writing down—analyzing and studying a lot of the almost infinite number of variables that affect our human material—trying to see the relation and inter-relation of these elements.

About this time someone is due to rise up and tell me that I am not talking about engineering or about business, but about psychology. All right, call it by any name you please. (I think the word "psychology" is one of those abused and over-worked terms like "efficiency.") As a word it should perhaps be given a rest.

But the essential point is this: The human side of industry never meant anything very definite to industry until it was attacked by essentially sound engineering methods.

SCHOOL OF MECHANICAL ENGINEERING
1874-1921

By Professor G. A. Young,
Head of School of Mechanical Engineering

Historical

A history of the beginning of the School of Mechanical Engineering will of necessity be general in recounting some of the plans and conditions leading up to the organization of this department in engineering. In 1874, the plan of organization adopted by the Board of Trustees of Purdue University was based upon the theory of special education and plans were made to arrange for instructions in the following special schools: Natural Science, Agriculture and Engineering. Detailed courses of study were adopted at the same time in Agriculture, Chemistry, Physics, Engineering and Mechanical Engineering, followed immediately by public announcement. Another reorganization took place in 1879 and the university plan of study was made to embrace three courses, the Scientific, Agricultural and Mechanical. Prof. D. G. Herron was professor of Mathematics and Engineering and W. F. M. Goss left Massachusetts Institute of Technology, where he was a junior engineering student, to become Instructor in Mechanics.

In 1881, Lieutenant Hamilton was appointed instructor in Engineering and Military Tactics. The next year Mr. Goss was made professor of Practical Mechanics, a position which he held for nine years until it was turned over to Prof. M. J. Golden. The engineering faculty in 1883 consisted of A. W. Stahl, professor of Physics and Mechanical Engineering; Prof. Goss, Practical Mechanics and J. E. Clapper, assistant in Practical Mechanics. Mr. Clapper resigned in 1884 and his place was taken by E. A. Dillon, who continued until 1885, when "Mike" came to Purdue as instructor in Practical Mechanics.

In 1884, the trustees and faculty decided to confer the degree of Mechanical Engineer (M. E.) on all students completing the course of study in the schools, Practical Mechanics and Engineering.

Early Equipment

The work in Practical Mechanics and Engineering was started in the basement of the building now known as the Pharmacy Building. It then covered but half the ground that it does at present. It is interesting to read from the catalog of 1884 the description of the "wonderful equipment" which comprised the engineering laboratory and shops. It is listed as follows:

9 wood working benches with tools,
5 wood turning lathes,
1 circular saw,
1 scroll saw,
8 vises with chisels, squares and calipers for each,
5 forges, four of which were furnished with air blast by power,
3 iron lathes,
1 speed lathe,
1 machine planer,
1 vertical drill with complete set of drills,
1 Deane steam pump for experimental purposes.

Engineering students were "allowed to go into the engine and boiler rooms and look at the engine run."

Important Events of 1885

The year 1885 was a momentous one for engineering at Purdue University. It is noted for three important events.

First.—The first man to receive a degree in Engineering was given the degree of Mechanical Engineering (M. E.) in June of this year. His name is Charles L. Ratliff and now he lives at New Castle, Indiana.

Second.—The dedication of the new shops and laboratories took place at this time. This building (now known as the Science Hall) was the most complete and largest of its kind in the country. It is interesting to note that the work in engineering and practical mechanics outgrew this building in less than ten years.

Third.—This eventful year of 1885 brought M. J. Golden to Purdue University. For thirty years he has been known to the students of Purdue as "Mike." Feared by the Freshman, respected by the Sophomore, eppreciated by the Junior, loved by the Senior and revered by the alumnus, it is safe to say that no one man ever had such a wholesome and lasting influence upon the lives of Purdue men as Professor Golden.

Increased Interest

Beginning with 1885, the School of Mechanical Engineering started the growth which made it the leading school in engineering at Purdue and in the interest of honesty, one must say, the leading school of engineering in the west. The next year found sixty students in

Mechanical Engineering, although courses in Electrical Engineering were started in this year, while the School of Civil Engineering had been started the year previous. Under Professor Goss, the Experimental Engineering laboratories connected with mechanical engineering developed until about 1892 when the main building, the present Mechanical Engineering Building, was constructed. This was made possible by the gift of Amos Heavilon and friends of the University living in Tippecanoe county. All the work of Mechanical and Civil Engineering was conducted in this building. This year, 1893, saw the installation of the first locomotive, Schenectady No. 3, in the Engineering Laboratory.

The new engineering building with its shops and laboratories was dedicated January 21st, 1894. Two days after, the main building, laboratories and part of shop wings were completely destroyed by fire. Within two years, the present building was rebuilt on the same plans as the one burned. The locomotive which was in this fire when rebuilt was placed in the present locomotive laboratory.

In June of this year fifteen degrees were given in Mechanical Engineering.

Steady Growth Continues

The twelve years intervening between 1894 and 1906 produced many changes in the staff of instructors and equipment of the Department of Mechanical Engineering, under Professor Goss' direction. During this time, Professors Ludy, Young and Veal were graduated and immediately took up positions as assistants in the laboratories and design room. In 1901, Professor Goss was made Dean of Engineering and Director of the Engineering Laboratories. The departments of mechanical and civil engineering jointly housed in the present mechanical engineering building with the department of practical mechanics became so crowded that more room was needed. This was accomplished in 1906 by the completion of the present civil engineering building. This year ended Dean Goss' long term of service with Purdue University. From the beginning of engineering at Purdue, for twenty-seven years his hand and mind had been directing the work along these lines into greater and greater fields of influence and efficiency.

The fall of 1907 found C. H. Benjamin installed as Dean of Engineering. Dr. Hatt, for ten years a member of this department, was made head of the Department of

Civil Engineering. The Department of Applied Mechanics, until now a part of the School of Mechanical Engineering, and the present department of Applied Mechanics, with Prof. R. G. Dukes as head, were organized.

In 1911, during the year's leave of absence of Professor Ludy, Prof. G. A. Young was in charge of the department of mechanical engineering. Upon his return to Purdue the following year, at his own request, Professor Ludy was made professor of Experimental Engineering and Professor Young was the first appointed head of the School of Mechanical Engineering.

During this year, the buildings of the department of practical mechanics were completed and the wings of the present mechanical building were made available for new laboratories.

HISTORICAL SKETCH OF THE SCHOOL OF ELECTRICAL ENGINEERING, PURDUE UNIVERSITY

By **Professor C. Francis Harding,**
Head of School of Electrical Engineering

The School of Electrical Engineering was formally established by the Trustees of Purdue University in 1888. It is the third of the Engineering Schools in the order of establishment, the first being the School of Mechanics and Engineering (later the School of Mechanical Engineering) and the second being the School of Civil Engineering.

Prior to the organization of a separate School of Electrical Engineering a course in Applied Electricity was administered by Professor Huston, at that time professor of Physics and later professor of Agricultural Chemistry. This course was elective for students of Mechanical Engineering and of General Science. In 1888, Prof. Louis Bell, who later attained eminence as a consulting engineer in the field of illuminating engineering, was made professor of Physics and Applied Electricity. The courses of study in Applied Electricity were increased to a two-hour class room and six-hour laboratory course in the Junior year and two-hour class room and eight-hour laboratory course in the Senior year. Electrical designing was included among the topics of the Senior course. During this year the students of Electrical Engineering numbered four juniors, ten sophomores and twenty freshmen.

From 1889 to 1892, Prof. A. P. Carman was professor of Physics and Applied Electricity. During this period the Senior courses were increased by one hour per week and a course was introduced in Electrical Machinery Design administered by Professor Carman and Professor Flather, of the School of Mechanical Engineering. In 1892 the Physics Department was separated from the Electrical Engineering. Prof. F. A. Waterman became professor of Physics and Prof. R. A. Fessenden, who later became famous for his work in radio telegraphy and telephony, became head of the School of Electrical Engineering. Professor Fessenden held this position only one year and was succeeded in 1893 by Prof. H. B. Smith, who later became head of the Department of Electrical Engineering at Worcester Polytechnic Institute. Prof. W. E. Goldsborough came in 1893 as associate professor and succeeded Professor Smith as head of the school when the latter left in 1896.

The Electrical Engineering Building was erected in 1890 and was occupied jointly by the School of Electrical Engineering and the Department of Physics. The first electrical machinery owned by the University was installed in the Mechanical Laboratory which stood on the site of Coulter Hall. After the completion of the Electrical Engineering Building these machines were transferred to the Main Electrical Laboratory, which occupied the room now used as a high tension laboratory. The power for driving the machinery was supplied by a 22-horse-power straight line engine. Among the machines were an original Gramme dynamo, Brush and Thompson-Houston arc machines, an Edison incandescent lighting machine, a T.-H. 5 hp. motor and other smaller machines. A Slattery 133-cycle alternator was added to the equipment in the early nineties. Several years later, additions were made to the laboratory by the erection of a dynamo laboratory to the east of the original laboratory. This building was torn down to make way for the present lecture room. In this room was installed a 100 hp. McEwen high-speed, tandem compound non-condensing engine which drove a three-inch line shaft to which the various machines were belted. One of the machines added about this time was a 50 kva. General Electric monocyclic alternator.

When Professor Goldsborough was made head of the school Prof. C. P. Matthews came as associate professor. A year later, in 1897, J. W. Esterline began his connection with the University as an instructor in Electrical

Laboratory. During the succeeding years, these two men carried on important research work along with their duties as teachers. Professor Matthews made extensive studies of electric lighting and numerous improvements in methods of photometric measurements. Professor Esterline carried on a line of research on the magnetic properties of iron and steel and invented an instrument for making commercial tests.

From the beginning of the school until 1898 the degree awarded graduates in Electrical Engineering was that of Bachelor of Mechanical Engineering. In 1898 the degree was changed to its present form, Bachelor of Science in Electrical Engineering. The number of graduates in 1894 was 23. The number increased to 30 in 1896 and then gradually decreased to 15 in 1900, after which the number increased rapidly. This decrease in the late 90's was observed at all the principal engineering schools.

In 1901 the telephone interests of Indiana became interested in Purdue and through their efforts a department of Telephone Engineering was established with Prof. J. C. Kelsey in charge. Telephone Engineering students were required to take the regular work of the electrical course except that some courses given in the mechanical and other schools were omitted and special courses in telephone subjects taken.

During the Exposition at St. Louis in 1904, the University made an extensive exhibit of its work, and Professors Goldsborough and Kelsey spent much time at St. Louis in connection with the Electrical Engineering portion of the exhibit. In 1905 Professor Goldsborough severed his connection with the University to take a position with the engineering firm of J. G. White & Co. He was succeeded by Professor Matthews, who had been associated with the school since 1896. Professor Kelsey was succeeded by Arthur Bessey Smith, who came in 1905. Prof. A. N. Topping, who is the oldest man in the point of service of the present staff of the school, came to Purdue in 1903.

During the years following 1900 the number of students in Electrical Engineering grew rapidly and increased space became necessary. The erection of the Physics Building in 1904 relieved the congestion somewhat, as the space used by the Physics Laboratories became available for Electrical Engineering. In 1906 the construction of the new laboratory wing afforded the relief necessary. The McEwen engine and the dynamo laboratory equipment were installed in the new laboratory in that year.

In 1907, Professor Matthews was compelled to take a leave of absence on account of failing health and Professor Esterline became acting head of the school. A trip to the west failed to improve the health of Professor Matthews and he died in California during the school year of 1907-1908. Professor Esterline remained in charge of the school until the appointment, in 1908, of Prof. C. Francis Harding, the present head of the School of Electrical Engineering.

In 1909 and 1910 a number of improvements were made in the equipment of the school. The test car was refitted and placed in service and the tracks of the test car pit were connected with the city car system. The Thordardsen high voltage transformer which was secured after the St. Louis Exposition, was rebuilt and installed in the room formerly used as a dynamo laboratory. Following the installation of the high-voltage transformer was begun the series of investigations of high-voltage phenomena that have formed the subjects of a number of scientific and technical papers by Professor Harding and assistants.

From the establishment of the school until 1901 only one line of work in general Electrical Engineering was offered to students. After 1901 students had the option between the telephone work and the general course. Additional electives were offered in 1910 giving choice between Electric Railway Engineering, Illuminating Engineering, Analytical Electrical Engineering. The course in Telephone Engineering still continued to have a larger amount of specialized work than the other courses until 1914, when they were all placed on the same basis.

The most important changes in the equipment of the school in recent years have been the installation of a new motor generator set consisting of two 25 kw. direct current generators direct connected to a 75 hp. synchronous motor to replace the steam-engine driven machines in the general laboratory, and the installation of a new high-voltage equipment in 1918-1919. The latter equipment consists of two 135 kva. transformers having a secondary voltage of 300,000 volts each and is equipped with very elaborate control apparatus. A radio station having a range of about 1,000 miles was installed in 1920.

During the last few years there have been few changes in the staff of the school. Professor Topping has been connected with the school continuously since 1903, Professor Harding came in 1908, and Professors Ewing, Still and Rowell in 1912. Professor Curtner began his connection as an instructor in 1911 and was promoted to assistant professor in 1920. Professor Achatz came in 1913 and Professor Blalock came as a graduate student assistant in 1916 and has remained here since. Mr. Pugh and Mr. Bailey joined the staff in 1917 and 1920.

Mr. Emrick has acted in the combined capacity of instructor in Electrical Engineering and Director of the Purdue University Band since 1908. The research work in electrical engineering is carried on for the Engineering Experiment Station by Mr. K. B. McEachron, who devotes a portion of his time to instructional work.

HISTORY OF THE SCHOOL OF CIVIL ENGINEERING

By Dr. W. K. Hatt,
Head of School of Civil Engineering

The first class was graduated from the School of Civil Engineering in 1888. It occupied its own home in the present Civil Engineering Building in 1905. Although a comparatively young school it numbers some distinguished engineers in its alumni.

The ideal of the school is thorough teaching by professors, who are also competent practitioners. The several departments of Topographical Engineering, Laboratory for Testing Materials, Hydraulic Laboratory, Railroad, Highway, Sanitary and Structural Engineering are directed by men who are expert in the practice work of Civil Engineering. There is a Civil Surveying Camp for eight weeks between the freshman and sophomore years. This in connection with the work of the year serves to produce a unity of purpose on the part of the student in the school.

The school maintains active contact with the public works of the State, and the professors give advice and other service to the various state departments. The Laboratory for Testing Materials is the official testing laboratory of the Indiana State Highway Commission. The professor of Civil Engineering is the Indiana State Highway Engineer. The Department of Highway Extension conducts a Road School each winter which is attended by the county highway superintendents. The Department of Hydraulic and Sanitary Engineering advises the State Conservation Commission.

The research work of the school is well known. The Hydraulic Laboratory has contributed several bulletins giving the results of investigation of sprinkler nozzles, for sewage purification plants, the flow of water through various kinds of pipe. A new form of parabolic weir has been developed for an automatic metering of the flow of water. The early researches of the Laboratory for Testing Materials in the reinforced concrete construction and the later investigations of the road building materials of Indiana, have proved of value and have reduced the cost of road construction.

The graduates of the School of Civil Engineering have many possibitities of professional activity. Many of them settle down and open engineering offices conducting a very profitable business. The staffs of the bridge companies and the railroads contain many of our prominent alumni. Several contractors have become wealthy in construction. The Public Service Commission, the Highway Commission and the offices of the city engineers of Indiana are well supplied with Purdue alumni. Of late years graduates have been developing the sales departments of corporations manufacturing materials entering into construction and machinery used in construction.

Thus the three departments of Civil Engineering work, namely, designing, constructing and the field of management, offer attractive fields of work for our graduates. Those graduates, who do not wish to specialize, are prepared to conduct private engineering business and equipped to carry on ordinary work of such an office, including surveys, design of water works and sewage systems, design and construction of bridges, development and use of hydraulic power, survey and location of railroads, irrigation, and drainage.

The field of foreign service is becoming increasingly attractive. Our graduates are found in South America, Philippines, China, Central America and scattered throughout the near East.

The civil engineer deals with broad public questions. In addition to his thorough scientific training and technical preparation he must communicate his ideas to boards of commissioners and other bodies of laymen. He, therefore, needs good training in English and public speaking. A bridge is to him something more than a collection of members with enough material to carry the loads. It must be properly related to the necessities of the community. Constructions involve the legal rights of the individual and he must understand the principles of engineering law.

It is with these various duties in mind that the course in Civil Engineering has been designed on a broad basis, fitting a man for activity in almost any department of engineering affairs.

In attendance the School of Civil Engineering has kept pace with the largest of the schools, and from time to time has been among the three largest schools in Civil Engineering in the United States.

THE SCHOOL OF CHEMICAL ENGINEERING, PURDUE UNIVERSITY

By PROFESSOR H. C. PEFFER,
Head of School of Chemical Engineering

Purdue was one of the pioneers in Chemical Engineering in the United States.

In 1907, a course of study was instituted, leading to the degree of Bachelor of Science in Chemical Engineering.

This course was the result of the work of a committee of which President Stone; Dean Goss, of the Engineering Schools and Prof. P. N. Evans, of the Department of Chemistry, were members.

The first graduate in Chemical Engineering was B. M. Ferguson, '09, sales engineer for the Graver Corporation, Chicago. E. T. Plank, the only graduate in 1910, is now located at Birmingham, Ala., as superintendent of coking plant for the Gulf States Steel Co.

In 1911 Chemical Engineering attained the status of a school with H. C. Peffer as its head, which position he still occupies.

The school has, in spite of strict requirements, grown much beyond the scope originally intended, and is now operating under the disadvantage of lack of quarters and staff.

The graduates of the school are distributed as follows:

Chemical Engineers, Operating, Production, etc.	14.2%
Testing, Experimental Research	7.1%
Metallurgy, Engineers, Superintendents, Technical Supervisors	44.9%
Chemists, Analytical and Control	15.6%
Research	4.1%
Business	6.4%
Teaching	2.7%
Miscellaneous	5.0%

Chemical Engineering at Purdue is founded primarily on a thorough training in the fundamental subjects underlying all engineering and, further, on the fact that leadership in specialized lines can only be built on such a foundation.

It is maintained by the leaders in engineering and chemistry that the best practical men are those who start with a thorough training in the fundamentals of their profession.

The standards laid down and maintained in this school result in a relatively small number of graduates well trained and adapted for the broad field and opportunities of their profession, and Purdue graduates in Chemical Engineering are in good repute wherever known.

ISOPROPYL ALCOHOL

By R. B. Lebo, Ch. '17

Laboratory of Chemical Products Division, Standard Oil Co.
(New Jersey), Rahway, N. J.

Isopropyl alcohol, commercially known as "PETROHOL," represents the latest development in the petroleum industry; the usage of a material heretofore valuable only as a fuel and the advancement of knowledge in that field of chemistry dealing with secondary alcohols.

All textbooks of organic chemistry mention the conversion of olefin to alcohol by the action of sulphuric acid, giving the formation of ethyl alcohol from ethylene as an example. Isopropyl alcohol was first produced from propylene in 1857 by Berthlot. In the early work very little, if anything, was done towards controlling conditions to obtain maximum yields.

In 1916, the first really serious attempt at studying this reaction for commercial application was started. A great difference is noticed in that ethylene is hardly attacked by 93% sulphuric acid at ordinary temperatures, while the higher olefins are readily absorbed even in weaker acid. With strong acid, a side reaction forming olefin polymers is aided, but which can be controlled by varying the acid strength. Several independent workers have found 87% acid to be most suitable.

The first raw material used was highly cracked gasoline as obtained from pressure cracking processes, containing mainly amylene (C_5H_{10}) and hexylene (C_6H_{12}). On treating this material with sulphuric acid of a sp. gr. 1.80 and maintaining the temperature near 20°C, the corresponding secondary alcohols were obtained. These alcohols proved to be satisfactory as a substitute for fusel oil of fermentation.

During the war, attention was called to the great need of acetone and the possibility of making it from isopropyl alcohol. The oil refineries produce large quantities of gas from petroleum distillations and especially that from cracking processes contain propylene (a gas), which is the raw material for isopropyl alcohol. Work was therefore started on using gas as a raw material. Here the difficulty comes in producing the intimate contact necessary for facilitating the reaction between a gas and a liquid. Again, acid strength and temperature to produce minimum polymerization is important. Little headway was made until the idea of adding oil as a carrier, or, one might say, as a catalyst between the gaseous olefin and acid was conceived. The olefin dissolves in the oil first and is then reacted on by the acid, the reaction proceeding much faster due to the increased solubility of the olefin in the reaction mixture (composed of oil and acid), and the greater surface of acid in contact with olefin. From here on, things in general picked up and the process became practical.

There can be no doubt that the petroleum industry is the logical place for carrying out this process. For its operation an abundant and cheap supply of the raw material (olefin) must be had. From petroleum distillation in the largest refineries, millions of cubic feet of gas are produced daily which is all consumed as fuel. This gas has a content of 5% to 30% olefin, depending on its source, i. e., the nature of the oil and the method of distillation. The olefin content of the gas may be composed of propylene, butylene, amylene, hexylene, the proportions depending greatly on the way the oil is handled in distillation. All of these olefins may be absorbed by sulphuric acid and converted to alcohol or polymer. On an estimated refining capacity of the refineries of this country, 156 million cubic feet of gas are produced daily. This is estimated to have an olefin content of 9-10% which gives the estimated possible production of 260,000 gallons of alcohol per day, consisting of propyl, butyl, amyl, hexyl, and even higher alcohols.

The chemistry of the process is represented by two simple equations which every student of organic chemistry knows. When propylene is passed into cold sulphuric acid, propyl hydrogen sulphate results, which is relatively unstable, thus:

$$C_8H_6+H_2SO_4 = C_8H_7OSO_3H$$

The propyl hydrogen sulphate when added to water, hydrolyses giving isopropyl alcohol and the sulphuric acid that we started with:

$$C_3H_7OSO_3H+H_2O = C_8H_7OH+H_2SO_4$$

The alcohol may be distilled off, leaving the acid behind to be reconcentrated and used again. The first reaction is carried out in a tower designed to give good contact between the acid and gas, while no complicated apparatus is required for the second reaction. The mixture of the hydrogen sulphates (acid extract) as obtained is amber in color and is of a syrupy character. When this acid extract is diluted with water, an oily material separates on top which is composed to a large extent of olefine polymers.

Since all the olefins of the gas react, a series of alcohols are obtained, some being water soluble and some water insoluble, and by this difference isopropyl alcohol is separated from the higher members as a weak water solution and is then ready for purification and distillation. The following table shows the change in boiling point some olefins undergo on conversion into the corresponding alcohol.

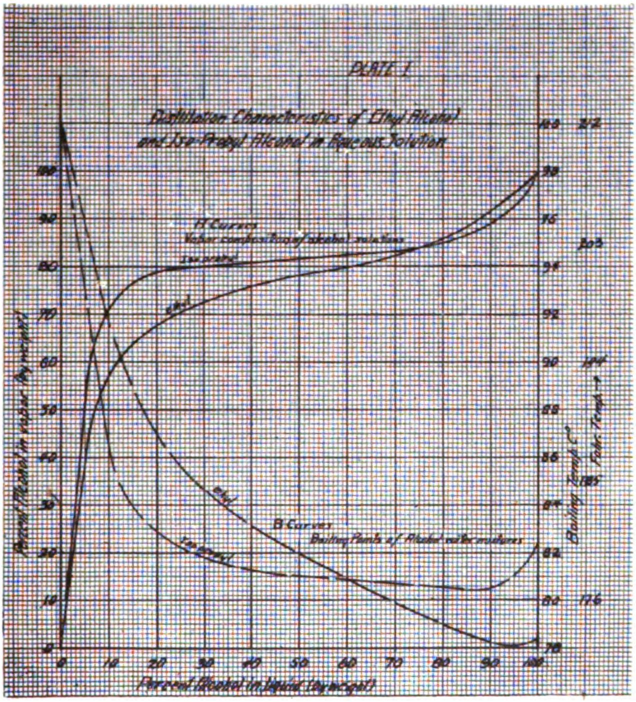


TABLE I.

Olefin			Alcohol		
Propylene	C_3H_6	48. °C	Isopropyl alc	C_3H_7OH	82.4°C
Butylene	C_4H_8	2.5°	sec butyl	C_4H_9OH	99.8°
Amylene	C_5H_{10}	36. °	sec amyl	$C_5H_{11}OH$	116. °
Hexylene	C_6H_{12}	69. °	sec hexyl	$C_6H_{13}OH$	136. °

Summing up: olefins higher than ethylene can be converted to their corresponding alcohols by the aid of sulphuric acid. Several workers have published data showing that acid of 1.80 sp. gr. gives best yields. No two members of the olefin series react the same towards sulphuric acid, some tending to give a higher polymer yield. The alcohols produced from petroleum olefin are all secondary or tertiary, a classification due to structure. Their odor is not disagreeable or choking like fusel oil products, but resemble ethyl alcohol in this respect. Alcohols having 7, 8 and 9 carbon atoms have been prepared from petroleum products. When purified these high alcohols possess flower-like odors.

Heretofore isopropyl alcohol belonged to the class of rare chemicals and was usually made on a laboratory scale only for use in scientific investigation. But now it becomes of economic importance. Isopropyl and ethyl alcohol are so similar in many respects that it is advisable to tabulate their physical properties. The name isopropyl alcohol is really incorrect and should be secondary propyl alcohol, but general usage demands the first.

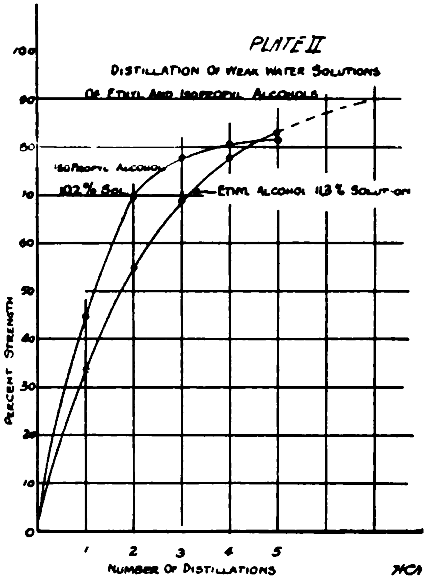


TABLE II

Properties of Ethyl and Isopropyl Alcohol

		Isopropyl	Ethyl
1.	Molecular weight	60.06	48.05
2	Formula	$CH_3CHOHCH_3$	C_2H_5-OH
3.	Boiling point (760m/m)	82.4°C-180°F	78.3°C-173°F
4.	Specific gravity 20°/4C	.7855	.7893
5.	Constant boiling mixture with water	80.4°C-176.4°F	78.1°C-172.5°F
	Composition of mixture	87.7% wt. 91.1% vol.	95.6% wt. 97.4% vol.
	Specific gravity of mixture 20°/4C	.8158	.7973
6.	Index of refraction ND/25	1.3749	1.3833
7.	Miscibility with water		
8.	Heat of evaporation (B. t. u. per pound)	290	423
9.	Specific heat of liquid	.775	.612
10.	Specific heat of vapor	.448	.453
11.	Critical temperature	243.5°C 470.3°F	243.1°C 469.6°F
12.	Critical pressure (atmospheres)	53	63
13.	Heat of combustion (B. t. u. per pound)	Cy 14416	Cy 12180

Distillation Characteristics

Both alcohols form with water mixtures of definite composition which remain unchanged on distillation and have boiling points lower than the dry alcohol. Thus from aqueous solutions of alcohol, only a certain maximum strength can be obtained by rectification (see Table I for composition of low boiling mixture). The ease with which alcohol is brought to this maximum strength is of great importance to the user of alcoholic solutions and the designer of rectifying columns.

The curves of Plate I bring out this point. The (A) curves show the composition of the vapor evolved from a boiling solution of a given strength. Thus for a liquor containing 10% of either alcohol, the vapor would contain 59% in the case of ethyl alcohol and 72% in the case of isopropyl alcohol. The (B) curves give 90.5°C as the boiling point of 10% ethyl alcohol and 86° for 10% isopropyl.

That isopropyl alcohol is easy to rectify is borne out by the fact that by one distillation through a rectifying column practically 87.7% alcohol is produced, while with commercial grain alcohol only 92.5% strength is obtained, which is 3% below the low boiling mixture. The curves of Plate II show the rise in strength on repeated distillation of a 10% solution of each alcohol. Here the product from a previous distillation is redistilled without fractionation until all the alcohol is over. The strength of distillate is plotted against number of distillations. The curve for isopropyl alcohol rises the faster, and at the end of the fifth distillation there is a difference of 5% yet to go before reaching maximum strength, while for grain alcohol the difference is 12%. The (A) curves of Plate I show the same difference in rapidity of rise. For original data on this subject refer to Journal Ind. and Eng. Chemistry, Vol. 8, Pg. 2607, and Journal Am. Chem. Soc., May, 1921.

One important difference between the two alcohols is the solvent power for inorganic salts. While ethyl alcohol dissolves a large quantity of caustic soda, isopropyl alcohol dissolves but little, so that water may be readily salted out of aqueous solutions. Of course, this does not produce absolute alcohol, but a product of 99% strength can be made. This difference in solvent power for caustic serves as the basis of a method for determining the proportion of the two alcohols when present in a mixture.

The solvent power of "PETROHOL" for organic substances is believed to be generally greater than ethyl alcohol. Isopropyl alcohol of 91.1% strength dissolves three times as much butter fat as 95% ethyl alcohol. Solutions of equal weights of nitrocellulose in equal quantities of isopropyl and ethyl acetates show a decided difference in viscosity, that of the isopropyl acetate solution being higher. In making up liquid shellac, there is again quite a noticeable difference in viscosity provided the dry shellac contained some shellac wax. This difference may be expressed in terms of covering power of the liquid shellac. By using 3 pounds of shellac to a gallon of isopropyl alcohol, the same covering power is obtained as 4 pounds per gallon of grain alcohol.

The toxic effect of isopropyl alcohol, of course, attracts general attention. At present there is no well-founded research showing its behavior when taken internally. One article reports that acetone is formed by oxidation in the body, which is very likely true, as acetone is easily produced by oxidation. For external use, no objection has been found, several people reporting it as very beneficial. A hand and face lotion containing 20% isopropyl alcohol has been used for more than a year by several members of this laboratory without bad effects.

In a report of Dr. I. Macht, of Johns-Hopkins University, entitled "The Comparative Toxicity of Some Alcohols," the following is given: "The animals (rats) were confined in a chamber containing an open vessel suitably screened off and filled with the alcohol under test, so that the air of the chamber was saturated with their fumes. It was found that methyl alcohol quickly killed the rats, the latter succumbing in a day or two. Ethyl alcohol proved fatal also to the animals after exposure to its fumes for several days in a warm room. Rats confined in a chamber containing an open vessel with isopropyl alcohol in a warm room were little affected and were found to be apparently in normal health after a week's exposure."

As to chemical properties, isopropyl alcohol is similar to ethyl alcohol, except that it possesses those properties common to secondary alcohols. Isopropyl alcohol dehydrated with greater ease by most dehydrating agents to propylene or ether. With strong sulphuric acid, there is usually formed polymers. Isopropyl ether can be prepared by the action of sulphuric acid, but requiring weaker acid than for ethyl ether, also lower temperature.

The halogen acids unite with isopropyl alcohol with greater ease than ethyl alcohol, forming the chloride iodide or bromide. This is generally true of all secondary alcohols. With nitric acid, isopropyl nitrite is formed, which has the same properties and effects on the human system as "Sweet Spirits of Nitre" (Ethyl nitrite). Isopropyl alcohol is easily oxidized by copper catalysts to acetone in a relatively pure condition and with nearly quantitative yields. The product obtained passes British Ordnance specification without any special purification.

INDIANA'S HIGHWAY PROBLEM

By Ben H. Petty,
Instructor in Highway Engineering, Purdue University

One of the most urgent problems facing the State of Indiana at the present time is properly to construct and maintain a system of highways which will adequately handle existing and near future traffic. Prior to the coming of the heavy motor traffic, Indiana ranked among the first of good road states, primarily because of the fact that she was richly blessed in many localities with deposits of excellent gravel and stone for road surfacing.

Because of remarkable development of motor traffic many present day practices are in the nature of experiments. We strive for the best type of hard surface construction that will satisfactorily and economically carry the heavy traffic. As recently as 1909 a motor truck was a curiosity, yet at the present time there are approximately 35,000 registered in Indiana alone. The number of passenger automobiles has increased more than ten times in the same period, numbering around 300,000 in Indiana in 1921.

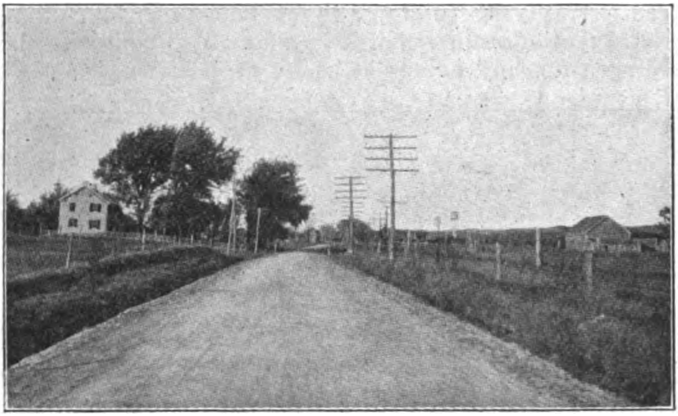
Many states soon realized the necessity of meeting these changed traffic conditions and created state highway commissions to handle the problem. Indiana was slow to follow suit. Our highway commission was not created until 1919, and has hardly had time to get properly organized and in efficient working order.

There are approximately 84,400 miles of roads in Indiana at the present time, distributed as follows:

State Roads	3,300 miles
County Roads	31,300 miles
Township Roads	49,800 miles

Practically all of the township roads, or 60 per cent. of the total, are dirt roads. Most of the county mileage is of the intermediate surface type, gravel or macadam. The State mileage includes some dirt roads, a large mileage of gravel and macadam surfaces, and about 400 miles of hard surfaced roads.

A study of the above statistics brings out some rather impressive facts. For instance, if Indiana's total road mileage were stretched out in a single line, it would reach around the earth almost three and one-half times. The fact that 60 per cent. of our highways are dirt roads will probably come as a shock to a great many Hoosiers, who have had no occasion to travel on the roads in the more backward counties of the state. In fact, the total dirt road mileage is greater than 60 per cent., since many of the county roads are in that class. Less than one-half of one per cent. of our highway system is hard-surfaced. About 3,000 miles of highway designated as State trunk roads are yet to be hard-surfaced. If one takes a conservative present-day estimate of $40,000 per mile, it would require $120,000,000 to complete the hard-surfacing of the State roads alone, which is only about 4 per cent. of the total mileage.



A Macadam Road in Good Condition

The total of the funds available for state highway construction this year is about $5,000,000. If we assume that we shall have an equal amount each year for state work, it would require 24 years to complete a program of paving our main trunk system alone with hard surfacing material, such as concrete, brick, asphalt, etc. Thus it will be seen that Indiana's fight to regain her standing in the column of good roads states by virtue of an adequate up-to-date highway system is just in its beginning.

Our State Highway Commission was created on April 18, 1919, when Governor Goodrich appointed Messrs. D. C. Jenkins, John T. Oliphant, Earl Crawford and Archy Campbell as Commissioners to serve one, two, three and four years, respectively. Mr. L. H. Wright was chosen as Director, H. K. Bishop, Chief Engineer of Construction, A. H. Hinkle, Chief Engineer of Maintenance, and Mrs. Helen Norton-Freeman, Chief Clerk of the Department.

The law imposed upon the Commission the duty of laying out a system of state highways which would reach every county seat and city of 5,000 inhabitants or more, making a network of highways to connect all the market centers of the State. Engineering parties were set to work at once to survey the routes selected for improvement first. Contracts were let for a total of 210 miles of hard-surfaced roads to be constructed during 1920. However, on account of the unfavorable conditions in transportation, labor, shortage of materials, etc., this program could not be carried out, and only about 75 miles were paved. With the funds available this year, including Federal Aid appropriation, it is planned to complete the 1920 program and extend it as far as possible.

A Neglected Gravel Road

The more notable accomplishments have been in the maintenance of the State roads. The State system as selected by the Commission was turned over to the State by the various counties at the beginning of 1920. Anticipating state control, many counties had done but very little maintenance work on the roads in question for several months previous to this time. Therefore, when the State Highway Commission assumed the task of maintenance, the roads as a whole were in poor condition. Thus the Maintenance Department was confronted in many localities with work which involved virtual reconstruction, including widening, ditching, and resurfacing.

The Maintenance Department is organized on a gang patrol system. Under the Chief Engineer of Maintenance are five division engineers, each in charge of a certain division of state roads with headquarters at Vincennes, Seymour, Greenfield, Monticello and Ft. Wayne. Under each division engineer there are five or more superintendents, each in charge of a half dozen or more patrolmen, a mechanic, and two or more gang foremen. A patrol is equipped with a motor truck, a light blade grader, two drags, a plow, and small tools.

Several states favor the "gang" patrol system, while others prefer the "one man" patrol system, in which a single patrolman is responsible for only seven or eight miles of road and spends his entire time on this limited section during the working season of the year.

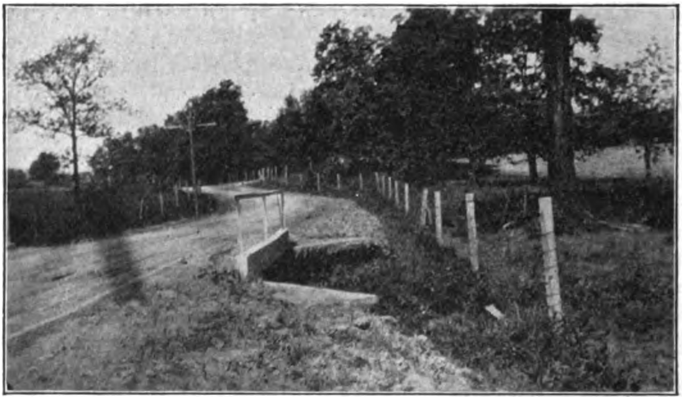
The funds for carrying on the State highway work are derived from three sources: (1) A maximum tax levy of 3.9 cents per $100 valuation of taxable property; (2) All net receipts from registration and fees derived from automobile registration in the state; (3) State inheritance tax. The first two sources yield about two one one-half million dollars each, while the last yields about half a million.

The county roads are maintained under the direction of a county highway superintendent, appointed by the county commissioners to serve two years at a salary of $4.00 per day. A marked improvement was made at the last legislature in the law covering this work. An amendment was passed providing that, beginning with 1922, the term of office of the county highway superintendent shall be four instead of two years, and in counties with 400 miles or over of county roads the salary shall be $5.00 per day. The commissioners may increase this salary if in their judgment it would be to the interest of the county to do so.

Each superintendent is entitled to an assistant for each 25 miles of county roads. These assistants are supposed to patrol their sections and keep the roads properly dragged and drainage ditches open. This work is done by team.

The funds for maintenance of county roads are derived from a tax levy not to exceed 1 cent on each $100 of valuation for each 10 miles of county roads. Therefore a county having 500 miles of roads could levy a tax of 50 cents on each $100 valuation of taxable property. The state tax board has in most cases reduced the maximum levies made by counties.

The construction of new county roads was greatly handicapped during the past season owing to inability to sell the bonds.



A Dangerous Condition—Bridge Too Narrow for the Road

Township roads are maintained under the direction of the township trustee. A township tax not to exceed 30 cents on each $100 of valuation may be levied for road and bridge purposes.

The foregoing is a very brief sketch of some of the problems, organizations, and laws involved in Indiana's highway problem. In conclusion, it might be said that the most urgent problem at the present time is that of proper maintenance of our existing roads. It is proper to carry out a well-planned program for gradually hard-surfacing our main trunk highways, but it is utter folly to rush blindly into an extravagant program, demanding all available funds for hard-surfacing to the neglect of maintenance on existing roads, as some of our misguided good roads enthusiasts would have us do. The thousands of our state citizens who live off the main traveled highways on the minor gravel and dirt roads must be considered in a just highway program.

We have millions of dollars invested in earth, gravel and stone roads and this investment must be properly safeguarded by adequate maintenance. A good slogan for Indiana at the present time is the one used in Wisconsin, "Let's keep what we have until we get more to keep."

TECHNICAL CONTROL IN INDUSTRY

By E. R. Crosby, Ch. '17,
Technical Foreman, Aluminum Manufacturers, Cleveland, Ohio.

Technical Control in the broader sense means the training of the practical man to think and work more scientifically and the teaching of the technical man, especially one just out of college, to make practical application of the analytical methods of thinking acquired in college to improve quality while reducing cost of manufacture of the product.

This article will deal more with technical men as related directly to management and production, although the basic principles involved in solving scientific problems will apply equally well to all technical graduates.

Young men have been going from our engineering schools for several years past into many lines of industry, but probably the first and the one that uses scientifically trained men to large extent has ben the steel industry. These men, as is the case in most industries, begin in a laboratory and work into the industry from there. Chemical industries have always been more or less controlled from the laboratory. In recent years graduates have been put directly into the plant on production jobs to control some important operation of the work or to cut down losses. Paper, rubber, glass, and numerous other industries can be mentioned that now in a large measure technically control their production.

It has been only in recent years that iron, brass, and especially aluminum foundries maintained any control other than a laboratory to analyze raw materials and to check occasionally the melter's mixtures. Practically the only time the finished product was checked was when some irate customer complained of the quality of delivered castings. Such were succession of after-thoughts or cures for the trouble rather than preventions. Control should be a means for keeping out, rather than getting out, of trouble.

The fundamental principles involved in the scientific control of production in any industry are the same. The scientific method of attacking any problem is to collect carefully all data bearing on the matter, analyze the data, and deduce from this the true laws which underlie the phenomenon, test the results by experimental determinations and record the entire proceeding. Such recorded information if accurately obtained is impersonal or scientific. Then if well defined rules are made to carry out these deductions which are of such vital importance to the process the problem will stay solved.

The basic principles are abstract and hold true regardless of the human element, though of course the effectiveness with which these principles may be applied depends greatly upon the latter factor. The graduate student will find upon entering the employ of any concern, that he must first get the co-operation of the men with whom he is associated. This co-operation includes the workmen, foremen, and superintendents, and indirectly the manager. One is always confronted with the fact that all are more or less prejudiced against any change from an old well established practice. The majority work by the "rule of thumb" method. A great deal of ingenuity and practice is required to win their confidence.

A good course in practical psychology would be worth while in any engineering curriculum. The power of suggestion is an important factor in winning the workman to new ideas. The workers' and foremen's ideas can be made to conform identically with the technically trained man's original idea if the workers are given the logical suggestions and their ideas directed to that one end. The worker must be made to know at the beginning that the college man is to be a help to him and not a hindrance. The college man must realize at the start that he is to get some valuable information from the worker. From this information he should be able to make analytical deductions that the worker is unable to make, and accomplish the end he has in view. The worker must be made to see, however, that he in like manner is materially benefited. It has been said that, after all, a college man's success depends upon five per cent college education and ninety-five per cent well directed common sense. It seems to me that the biggest factors obtained in college are the analytical training of the mind, the association of men, and a determination to complete successfully any task. Such a training enables one to think straight and draw logical conclusions. He should not only be able then to do his own work in the one best way, but also convey these principles to men with whom he is associated.

The underlying principle of industrial management, "the one best way to perform an operation," is merely the scientific way of attacking a production problem. Technical control may be considered an outgrowth of time study and industrial management. Further discussion in this article will be confined to the development and use of technical control in foundries, but the basic principles can be applied to the control of any manufacturing process.

A laboratory is first maintained to analyze raw material, in order to check purchase specifications. The analyses of materials gives the foundry man an idea as to the grades of material he has, and from these he roughly mixes his alloys to conform with some standard alloy. More often he mixes his metals by judging the composition of individual ingredients by external appearance or fracture. Formerly the laboratory was used only as an afterthought when a source of trouble arose. The chemist was looked upon to find out the mysterious —only the things the practical man knew nothing of. It was very common practice for the foundryman to give orders to his melters to make up his charge using one ingot of one lot, two ingots of another, and a box of scrap, thus expecting his mixture to conform with a standard alloy. By taking advantage of the opportunities offered in helping the foundryman out of difficulties the engineer was able to acquire knowledge of founding and convince him he was of more use than merely chasing molecules out of solution. Thus he gradually worked his way into the foundry. By careful observations and applications of scientific methods to the betterment of existing conditions the engineer soon becomes the nucleus of a technical organization which controls not only the raw materials, but each part of the process of fabrication.

The raw material problem is attacked first because of troubles which are due to the variation in quality of purchased material for which the man in the plant can not be held responsible. Mixtures are controlled direct from the laboratory by written instructions to the melting foreman on charge sheets showing the pounds of each lot or grade of metal to be used in each charge so as to produce the chemical composition desired in the alloy. A copy is also filed in the office. As the metal is charged to the furnaces the weights are recorded on a delivery sheet. At the end of the day such sheet is taken up by the metal stores clerk who makes out a daily metal room record which shows the total amounts of various kinds of metals used in each alloy as well as all metals received. This record is a perpetual inventory of metals on hand at the beginning and end of each day.

Such control insures a uniform alloy which can be made to meet chemical specifications, as the following results for the year on a standard alloy show:

The control aimed at was:

Element A 7.5%
Element B 1.5%
Element C 1.2%

Average of 350 analyses:

Element A 7.47%
Element B 1.62%
Element C 1.33%

In addition to making a uniform product such a control is instrumental in reducing the cost of manufacturing due to the efficient use of various grades of raw material and reclaimed industrial waste.

However, chemical composition is only the first step in the production of castings which will meet physical specifications; consequently melting conditions and practice should be studied with a view to establishing a standard melting practice. Such a practice involves an efficient pyrometric control and also a complete record of the metal from the time it leaves the charging floor until it is poured from the furnace.

Not only is the furnace room control a safeguard against overheated and soaked metal, but it is also a means of increasing production per furnace, inasmuch as the furnaces are poured as soon as the ready signal is given by the operator.

Remelted metal and foundry return scrap are important factors in the metal charged to the furnace and the technical man maintains a complete check on these proportions by means of the control records.

In order that metal may be transferred from the furnace to the mold with the least loss of heat and time, a pouring control is maintained on each job in the foundry. By observation and recording data the technical department has established the correct pouring temperature for each kind of casting, which is posted at each station, and this temperature must be maintained.

When the metal arrives at the pouring station, the time, the temperature, and the furnace from which the metal comes are recorded. The metal is poured at the standardized temperature for each casting. The time and temperature at which the casting is poured are then recorded, together with the casting number and job number. Thus a complete record of the history of the casting from the time the metal is received into the plant can be obtained by reference to the serial number on the casting. This is an important factor in attributing cause for complaints which are sometimes made several months later. As an additional check on the quality of the product, and in order to see that the standards of mixing, melting, and pouring have been maintained, tensile strength tests are made on each alloy daily, as well as chemical analyses taken from a test bar sample. A summary of these checks is made monthly and also yearly.

A summary of physical tests on No. 12 alloy for the year 1920, indicates the results of control.

Average Tensile Strength	Average Elongation	Specified Minimum T. S.	Specified Minimum Elongation	% falling below 19,000 lbs. Tensile Strength
20,800 lbs. per sq. in.	1.7%	19,000	1.0%	1%

The next step in control is the reduction of plant defective losses. It is a trying task to introduce any method of molding which is new. The old foundryman resents the invasion of his field with anything that might unveil the mystery with which it is surrounded. After exhausting his resources the molder invariably blames the metal for the cause of his troubles. The metallurgist is called from the laboratory and willingly shoulders the burden of proof. Since he has a complete record of the metal in the casting it is easy to ascertain whether standard practice has been followed. A majority of such accusations have no grounding and the difficulty can be overcome by a change in molding practice. Thus the technical man is able to co-operate for the production of castings with a reduction of defective loss.

If careful analytical deductions are made from close observation of the results of logical experiments and accurate record made of same, the one best way to make the casting in question can be determined. Alteration records are kept, giving each change made on the job under study, and also reasons for the change and results. In many cases photographs are taken as a means of recording the method used. A daily and cumulative defective report is kept of the job under consideration, analyzing the defects and giving the per cent attributed to each. Such a record shows a progressive result of the scientific deductions carried out.

The following data shows the results of applying technical control to specific jobs in the foundry, comparing the per cent defective for equal periods before and after the control was established.

	% Defective	
Job	Before control	After control established
1	45.2%	19.1%
2	24.0%	12.0%
3	48.0%	19.0%
4	17.3%	8.3%

It has not been, until very recent date, that the practical foundryman has realized that the scientific control of core making could mean much to the foundry. Defective losses often attributed to other sources are due to bad cores.

The factors entering into the making of the "best" core require equally as much control as that of the alloying and molding practice. The core mixtures must first be as economical as is consistent with the uniformity of hardness. The ingredients making up the core should first be analyzed and proportioned properly. Close analysis of the problem shows that certain outstanding variables must be reckoned with, such as the binder in the old sand, the natural bond in the new sand and, especially, the moisture content. Ramming is also an important factor affecting the hardness of cores and is the one that is largely dependent upon the human element. Baking time and temperature is another important factor in the production of good cores, and the ovens should be provided with an indicator so that the temperature of any oven may be read by the oven tender. Standardized test cores are made and tested daily under compression on an Olsen testing machine, a process which gives the crushing strength of the mixtures and a comparison of the hardness of the cores.

The development of technical control has changed the attitude of the workers from the old "rule of thumb" method to a scientific way of thinking and working. It is doubtful whether the present workers in our plant could do their work without the technical methods now employed.

The good of technical control is further evidenced by the fact that this past winter the superintendent of our plant has conducted a foreman's and production man's school. This school or, rather, club meets twice per month and discusses foundry problems, the majority of which are technical in nature. The last hour is devoted to problems in mechanical drawing to familiarize the men with blue prints and patterns. This school is, no doubt, the outgrowth of the interest of the men in scientific methods. At least this school linked with technical control has produced thinkers on the job. Therefore, it can be said that the value of control in any industry is not only the establishment of measuring variables which have heretofore been considered impracticable, but, what is more important, the sowing of the seeds of analytical methods of thinking in the minds of associates and workers.

THE PURIFICATION OF STEAM TURBINE LUBRICATING OIL

By E. M. May, '02,
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While bearing pressures in horizontal steam turbines are relatively low, the journal speed is higher than in any other type of prime mover and is accompanied by high temperature conducted to the bearings from the steam end. It is almost imperative that the oil film in the bearings should never be broken and with this end in view all modern turbines are equipped with a self-contained pressure oil circulating system. This system not only provides effective lubrication for the main and thrust bearings, but also serves to carry off heat generated in the bearings and in some makes of turbines with oil relay governors, oil under pressure is supplied by a circulating system for regulating the speed of the turbine. In cases where the oil film in the bearings has been broken the damage has always been very severe, resulting not only in burnt-out bearings but also in extensive damage to the blading and spindle, due to the unbalancing effect on the spindle caused by vibration which is set up by the friction in the bearings.

The trend in turbine design and operating practice imposes increasingly severe conditions upon the lubricant. The tendencies are towards higher steam pressures and higher superheat, giving greater temperatures to the bearings adjacent to the high pressure end of the unit. Bearing pressures are likely to go up and not down. Modern power plant economics demand that turbines be run for long continuous periods at or near their most economical load. The number of very large turbines increases owing to the lowering of water rate by size alone up to certain limits, and thus the investment in an earning power of such machines must be carefully and adequately insured against shutdowns and damage. This particularly applies to lubrication, which is one of the most vulnerable features of operation. There must be continuously maintained the widest possible margin of safety with the oil.

Steam turbine lubricating oil producers have succeeded in making an oil highly suited for these special needs. Therefore, the problem of continuously maintaining the lubricating oil in first-class condition is limited particularly to keeping the oil clean and dissipating the heat which it absorbs.

The oil circulating system is practically the same on all makes of turbines. The oil is supplied under pressure at the middle of each bearing and flows out at the ends. It returns by gravity to the oil reservoir located in the base of the unit. A rotary or other suitable pump, usually driven from the main spindle of the turbine, forces the oil from the reservoir through the oil cooler and thence to the piping leading to the bearings, of which there are usually four main bearings and one thrust bearing. All turbines are equipped with an auxiliary or stand-by pump to use in case of emergency, should the main pump for any reason fail to deliver the required pressure and volume.

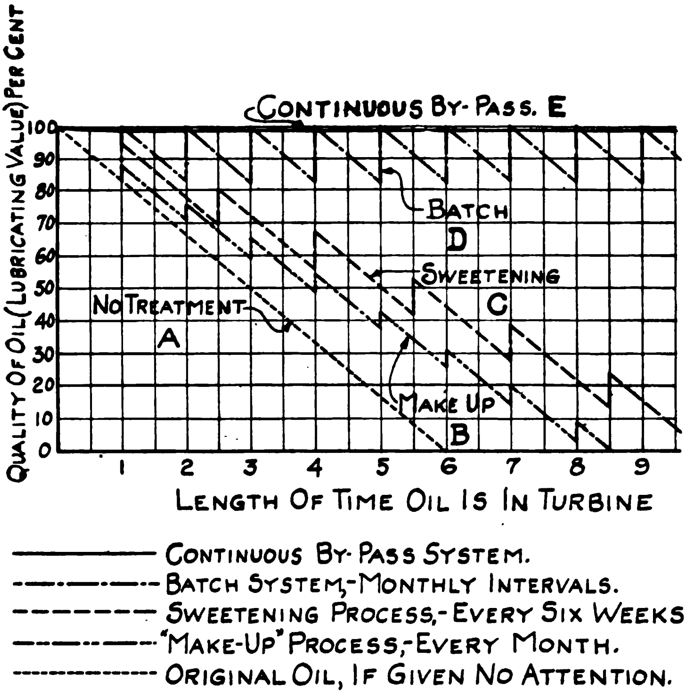

Figure 1

Great care has been exercised in the design of the bearings to permit operation at high speed, as many of the advantages of a steam turbine are secured from this feature. Special attention must be given to the selection and care of lubricating oil. A properly lubricated high speed bearing will not cause any more trouble than the low speed bearing. Oil pressures in bearings vary from 2 pounds to 15 pounds per square inch, depending upon the make and size of the turbine. The bearing temperatures sometimes reach 180° F., with 130° F. being a good normal operating temperature. The oil should be a pure petroleum product properly refined and with no admixture of any compound not derived from crude petroleum. The open cup flash point should not be below 315° F. and the viscosity at 100° F. should range from 150 to 310 seconds, Saybolt viscosimeter.

Most engineers are careful to select the best turbine lubricating oil to meet their conditions, but unless this oil is kept in shape, its lubricating value soon drops below that of a low grade oil. It is therefore obvious that it is best to procure the highest grade of oil and to provide means to keep it in first-class condition continually.

Assuming that the lubrication of a turbine is started with a high grade oil of the above specifications, we will analyze the possible sources of trouble.

The first of these is rapid circulation, which varies from seven to forty times per hour, depending on the size and make of the unit. This does not give the oil an opportunity to precipitate moisture or foreign matter picked up in its circulation, nor will it allow the elimination of air which may have found its way into the oil.

Moisture gets into the oil in various manners, in spite of the precaution taken by manufacturers. Sometimes it leaks through the packing glands or it may be due to condensation of moisture in the air when it comes in contact with the cool metal surfaces of the turbine oiling system. Very often there are water leakages in the oil cooler and in some makes of turbines the bearing shells are water cooled, and leakage sometimes permits this water to enter the oiling system.

The combination of water, air, heat, and the rapid circulation causes the oil to oxidize and readily form an emulsion, which results in a brownish colored sediment, most of which remains in suspension in the circulating system, if not continuously removed. It is important that not too heavy an oil be used so that no heat is generated, due to the internal or fluid friction of the oil itself, because this will not only cause oil trouble, but also a loss in power.

If water and air are continually removed from the oil, an emulsion, which is a mixture of water, air, and other foreign matter, will not accumulate.

One of the most natural causes of trouble in lubricating a steam turbine is due to emulsification of the oil, particularly when other impurities, such as grit and dirt, are present. This emulsion takes up dirt, particles of metal, and other foreign substances, and holds them in suspension so that they cannot readily precipitate.

Emulsion increases at an accelerating rate, once a small amount has accumulated, and finally becomes so thick that a "sludge" or "muck" will settle out and deposit on the cooling coils and in the oil passages and thus cause a dangerous rise in temperature of the entire body of oil in the system.

The formation of organic acids caused by the oxidation of the unsaturated compounds containing sulphur, nitrogen, and oxygen, is the first step in deterioration of steam turbine oil. This oxidation is greatly assisted by the presence of small particles of oxidized metals, dirt, or dust, which apparently act as catalytic agents absorbing oxygen and feeding it to the oil. The organic acids, being subjected to heat and pressure, are polymerized into both soluble and insoluble matter.

The so-called sulphonic acids are formed because of the treatment of the oil with sulphuric acid in refining, and unless these are entirely removed in the subsequent refining operations they will be broken down by the action of water and one of the resulting products is sulphuric acid. The presence of these acids increases the rate of oxidation of the oil, which in turn increases the tendency to form emulsions with water.

If continuous purification is carried on, the acid content of the oils after years of service is less than 1%, as the acid is entrapped in the impurities in the oil and continually removed.

A number of methods of maintaining the quality of turbine oil have been tried and the following shows step by step how the solution of the problem was reached.

Adding Make-up Oil and Sweetening

To make up for the oil lost by evaporation or leakage or withdrawing from the turbine oil reservoir a certain amount periodically and adding enough new oil to replace the amount so lost or removed, were the first steps to keep the oil in good condition. It was found that these methods were not effective because the impurities, such as emulsion, sludge, water, etc., were not removed entirely, but merely diluted.

Fig. 1 shows graphically the results of the various methods of purifying turbine oils. Curve "A" indicates the deterioration of oil without any attempt at purification. Assuming that new oil has 100% lubricating value and is used continually without any attention, curve "A" would indicate what takes place. The lubricating value of an oil will decrease until the danger point has been reached and it must then be removed and new oil put into the system.

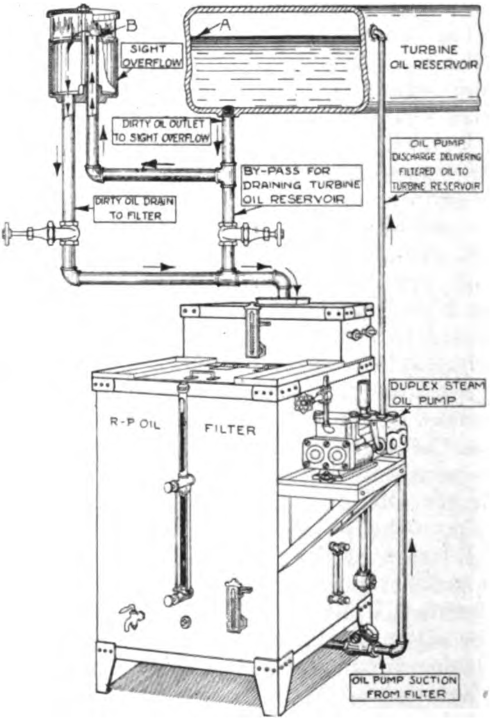
B
A
SIGHT OVERFLOW
TURBINE OIL RESERVOIR
DIRTY OIL OUTLET TO SIGHT OVERFLOW
OIL PUMP DISCHARGE DELIVERING FILTERED OIL TO TURBINE RESERVOIR
BY-PASS FOR DRAINING TURBINE OIL RESERVOIR
DIRTY OIL DRAIN TO FILTER
R-P OIL FILTER
DUPLEX STEAM OIL PUMP
OIL PUMP SUCTION FROM FILTER

Figure 2

Adding make-up slightly prolongs the life of the oil, as shown by curve "B." Sweetening as shown in curve "C" is little more effective than adding make-up, as it is only a question of time before the whole charge of oil is unfit for use, because the impurities are not entirely removed.

Batch Filtration

The next step is represented by curve "D," which shows the results of batch filtration and is an improvement over methods represented by curves "B" and "C." Batch filtration means withdrawing the entire oil charge from the lubricating system of the turbine at certain intervals, usually in the judgment of the operator. This used oil is immediately replaced by a fresh supply of clean oil and the used oil is subjected to a purification process which consists of heating the oil to a high temperature, precipitation, or possibly chemical treatment, etc.

The objectionable features to this method are that it is necessary to shut down the unit each time the oil is to be changed, and that this operation is left to the discretion of the operator. Invariably the oil is kept in the lubricating system for an excessive length of time making it unfit for use, with considerable risk of endangering the turbine. Furthermore, this system being intermittent, the duties of its operation cannot be performed by the personnel as efficiently as if it were assigned to a group of men continually engaged in this work.

Batch filtration is accomplished in two ways, that is, by means of a gravity type oil filter or a centrifugal separator, of both types of which there are several makes on the market. With either one of these methods it is necessary to subject the oil to violent treatment in order to remove effectively the impurities that have accumulated.

First, it must be heated to a high temperature to bring about the greatest difference possible between the specific gravity of the oil and the impurities to be removed. If a centrifugal purifier is used, tankage must be provided to hold the clean and the dirty oil.

Formerly when considering the matter of purifying turbine oil, the average engineer always had in mind oil in its very worst condition. By a simple method now commonly used, the moisture and other impurities which cause emulsion and sludge can be continually removed. It has been found that emulsion cannot take place if the impurities which cause it are removed as fast as they occur, and sludge will only form as the emulsion builds up. The sludge is the product of emulsion in the form of a thick and viscous coagulation which retains most of the impurities which have come in contact with the oil. **If emulsion is prevented sludge will not form.**

Continuous Filtration

In this system the oil leaving the bearings is filtered before it is returned to the turbine oil reservoir and is most positive and effective in maintaining the quality of the oil. However, the objection to such a system, especially for large units which require the handling of a great volume of oil, are the size of the filtering equipment and oil pumps and the space which they occupy, as well as the cost of installation.

Continuous By-Pass System

Curve E, Fig. 1, shows graphically what is accomplished with this type of system and which makes it possible to use the oil continuously and maintain a lubricating value equal to new oil. Thus, an oil of the very highest grade can be used economically because the oil in the system becomes an investment and not an expense.

A small amount of oil must, of course, be added from time to time to take care of the loss due to evaporation, leakage, etc., but what the limit of the useful life of a turbine oil is when purified by this continuous by-pass system is not yet known.

Turbines operating with this system have been in service for two and a half to three years, continuously using the original oil, with a slight amount added for make-up, and analyses show that there is no deterioration in the lubricating properties. Fig. 2 shows the application of the continuous by-pass system, and the first impression is that of its extreme simplicity, as it consists of a gravity oil filter, an oil pump, and a vented sight overflow fitting, and a small amount of pipe and fittings.

The system is trouble-proof, as stoppage of the pump, or filter, or both, simply leaves the turbine to operate the same as it would without the system. The oil level in the turbine reservoir is automatically maintained, as the level of the overflow pipe is permanently set to correspond to the desired level of oil in the reservoir. The outflow of oil to the filter is absolutely controlled by the amount of oil delivered to the turbine oil reservoir from the filter by the pump, as the overflow fitting is vented to prevent siphoning.

The reason that this system has proved so successful and is now almost universally used is, that it continually removes the agencies which, if allowed to accumulate, would cause the oil to emulsify and break down. With proper oil and clean circulating system there is no deterioration because of rapid circulation which keeps impurities in suspension, as the purification of the whole oil charge is so frequent that no sludge or muck accumulates. It is customary to by-pass all of the oil content in the turbine through the filter about once every hour.

Analyses of oil taken from any part of the reservoir or circulating system show the oil to be of good uniform quality with lubricating value equal to that of new oil.

By continuous by-pass purification the total content of sludge and liquid impurities distributed throughout the large volume of oil in the system is so small as to be negligible. This is shown graphically by Curve E, Fig. 1.

Another advantage is that the oil contained in the filter increases the total amount of oil in the system, which results in less work per gallon of oil. It also provides an effective safety device in case of excessive water leakage and is insurance against lubrication troubles at a cost which is insignificant when compared with that of the turbine which it protects.

A PLANT FOR THE COLLECTION, PURIFICATION AND TUBING OF NITON (RADIUM EMANATION) FROM A RADIUM SOLUTION

By Arthur L. Miller, Ch. E. '14,

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The apparently impossible task of collecting, purifying, and tubing the heaviest known gas, Niton, in quantities of one one-millionth of a gram, involving the efficient handling and winning this tiny quantity of gas from a mixture of gases of which it represents only a very tiny fraction of 1 per cent. of the total volume, has been accomplished in an eminently satisfactory manner.

The use of radium in quantities of 500 milligrams or more for therapeutic treatments is no longer a rarity, but is fast becoming common practice in order to properly treat the large numbers of patients seeking its benefits. In view of the monetary value of this agent, it would he highly desirable to employ a system whereby the possibilities of its loss can be reduced to a minimum or entirely eliminated.

The problem has been solved by using an apparatus for the collection, purification and tubing of the direct decay product from radium, namely, radium emanation, known chemically as Niton. While the principles employed are not new, the present apparatus is of comparatively recent development, being an improvement upon earlier systems, and within the last year or so has gained considerable standing on account of its compactness, simplicity, ease of operation and excellent efficiency.

To appreciate the work accomplished by the apparatus to be described, it is necessary to know the relationship of radium to its decay products which give off the rays used therapeutically. Radium is a metallic element in the alkaline earth group and behaves chemically like barium; however, during its life it is continually disintegrating into two gases, helium and niton; niton in turn decomposes into helium and a metal, radium A; radium A disintegrates into helium and a metal, radium B; radium B in turn into a metal, radium C. Since radium A, radium B and radium C are the elements producing the rays of therapeutic value, we are concerned only with a source of these metals which are of very short life. (See Table I.)

TABLE I

Element	Atomic wt.	Rays	Half Life
Radium	226.4	A	1,710 years
Niton	222.4	A	3.85 days
Radium A	218.	A	3.0 min.
Radium B	214.	Bγ	26.8 min.
Radium C	214.	ABγ	19.5 min.

The value for the half life of any radio-active element is the time required for 50 per cent. of a given weight to disintegrate. In twice this time it will be reduced to 25 per cent. and thus it continues to destroy itself one half each succeeding "half life," approaching, but theoretically never reaching, zero as a limit.

The decay of all known radio-active elements follows the same general course and can be represented by the same logarithmic curve by merely changing the figures along the time axis to conform to the half-life figure of the element under discussion.

From the above table it is obvious that niton is the direct source of the elements giving off the rays used; consequently, if it can be efficiently separated from its direct parent, radium, without physical handling of the latter, we will secure the benefits without risking the loss of a material the commercial value of which is approximately $3,500,000 per ounce.

The actual volume of gas to be handled is quite small as one gram of radium (element) produces per 24 hours only 0.1 cubic millimeters of niton at 0° centigrade and 760 millimeters barometric pressure; however, in order to successfully remove the niton it is necessary to have the radium in solution. Radium behaving chemically like barium, its chloride is soluble in water, and this salt is usually used dissolved in sulphate-free distilled water which has been made slightly acid with hydrochloric. The rays from radium and its decay products gradually decompose the solution into its elements, namely hydrogen, chlorine, oxygen and ozone. The volume of the gases produced by the decomposition of the solution is quite considerable, amounting to several cubic centimeters, thus causing a tremendous dilution of the niton per unit volume and greatly increasing the difficulty of producing concentrated or nearly pure niton.

To make it easier for the reader to follow the steps in the operation of the apparatus, a diagram of only one side, or one complete operating unit, is shown in Fig. II.

The apparatus proper is one continuous piece of glass comprised of bulbs, stopcocks and tubing fused and blown together in place, supported upon a steel frame 13"x44"x102", which is anchored in a block of concrete weighing upwards of 1,000 pounds. This construction insures a stable and rigid support for this rather extensive and fragile apparatus. (See Fig. I.)

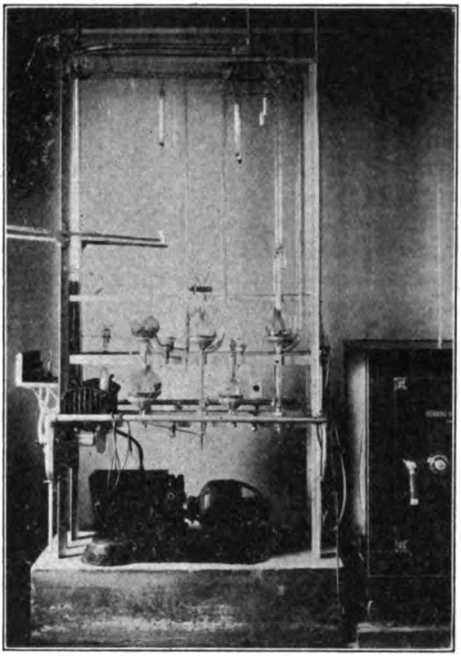

Figure I

The radium, in solution, is placed in bulb I, which is located in a safe or vault having a small hole in the top or side for the outlet tube connecting the radium flask with the apparatus proper. The safe can be locked after the radium solution is in place and need not be reopened for a year or more, or until such time as there are indications that it is necessary to replenish the water lost through decomposition and evaporation. This point is shown by a decreasing efficiency due to the retention of niton produced by the $RaCl_2 \cdot 2H_2O$, which has started to crystallize out of the solution.

By referring to Fig. II it will be observed that the apparatus is a series of interconnected mercury pumps, reservoir bulbs 21; 15; and 7, carrying, combined, something over 50 pounds of mercury. These reservoir bulbs take the place of the usual levelling vessel and the same results are obtained by using atmospheric pressure and a two-stage oil-sealed vacuum pump, which will produce a pressure of 0.001 mm. absolute.

When the apparatus is in working order a high vacuum is maintained in all parts except the reservoir bulbs, trap 25, drying tube 23 and line A.

The niton accumulates continuously, but is only pumped daily and usually at the same hour. The method of procedure is as follows:

With the vacuum pump running and stopcocks 22 and 8 set to give a vacuum in line A, cock 6 is opened allowing the mercury to flow from bulb 4 to 7, the mercury seeking the same level in tube joining 4 and 5 as in 7, equal degrees of vacuum being in 4 and 7 except for the pressure due to the gases being pumped and the water vapor present. This permits the accumulation of niton, etc, to diffuse in bulb 4. By turning stopcock 22 air is admitted through the drying tube 23 to the line A communicating with bulb 7, and upon opening stopcock 6, atmospheric air pressure raises the mercury in bulb 4, forcing the diffused gases through the mercury trap 3, into the purification chamber composed of sections 9, 10, and 11. The radium flask is pumped several times by repeating the above procedure. In practice, five to eight pumpings have been found sufficient to efficiently move the impure niton from the radium container to the purification system.

The sodium hydroxide (in 9) removes the carbon dioxide and hydrochloric acid; the coil of electrically heated copper oxide (10) causes the hydrogen and oxygen to recombine, providing oxygen for the excess hydrogen. Tube 11 is lined internally with phosphorus pentoxide which has been purified by sublimation under reduced pressure. This tube promptly absorbs any water vapor present, thus completing the purification of the niton.

The second step is to pump the purified gas from the purifying system into the capillary tube 18, the procedure being as follows: Vacuum is re-established in line A; stopcock 6 is closed when bulb 4 is about one-third full of mercury; close stopcock 8, restoring the original condition of the first pumping unit. Upon opening stopcock 14 the mercury in bulb 14 flows into reservoir 15, permitting the purified niton to diffuse into bulb

12. Air is admitted into line A and the mercury level in the U (17) is raised above the base of the U by opening stopcock 20, which is closed again. Cock 14 is opened, the mercury flowing from 15 into 12 pushes the diffused niton through stopcock 16, which is opened momentarily to permit its passage, together with about a cubic centimeter of mercury. The mercury is lowered in bulb 12 and the pumping process repeated a number of times. This is necessary, as the volume of gas being pumped is exceedingly small. After completion of the pumping, bulb 12 is left in its original condition, namely half full of mercury, and upon admitting air to reservoir 21 and opening stopcock 20 the mercury flows from 21, fills the U (17), pushing the purified niton to the end of tube 18, which is a very thin-walled capillary tube having an external diameter of about 0.7 mm. The pressure on the gas depends upon the mercury level in reservoir 21, which is located considerably below the tip or end of

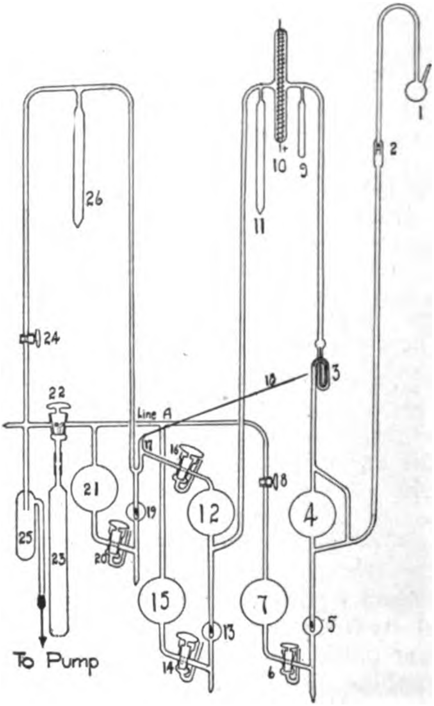

Figure 11

tube 18, making the maximum pressure about one-half the barometric. The mercury level, 21, can be controlled by closing stopcock 20, thus enabling the operator to vary the pressure between a few centimeters and the maximum, with the attendant and corresponding gas volumes. At the maximum pressure the niton from one gram of radium will occupy only a few millimeters of the capillary tube.

Even at the maximum pressure the niton is under only one-half atmospheric; hence heating the capillary with a fine pointed flame, the walls soften, fall together, and the tiny tube filled with niton can be drawn off without loss. Making further use of the needle flame, this finished tube may be divided and subdivided to produce tubes of the desired radio-activity. For protection against breakage in handling, these tiny tubes are housed in suitable metal jackets, and when aged are calibrated by comparison against a radium standard. Calibrated niton tubes can be used in the same manner as its radium equivalent, thus avoiding the possibility of permanent loss, as the radium is never handled and always remains in the locked safe, while the niton tube completely decays in 30 days regardless of what may be done with it.

The time for aging niton tubes is 3½ hours after final sealing. This time is required for the decay products, radium A, radium B, and radium C to come into equilibrium with each other and their ancestor, niton. Upon attaining equilibrium the tube shows its maximum beta and gamma ray activity, decaying at the rate of 16.47% every 24 hours thereafter, reaching half the initial value in 3.85 days and becoming entirely useless in 30 days.

If the apparatus is operated for 30 days and no tubes lost or broken, the tube drawn off on the 31st day will just compensate for the amount of decay of the previous tubes, thus balancing the system. Following the same thought, if an entire day's accumulation of niton is lost, the matter is of small importance, as the loss in 3.85 days dwindles to one-half, in a week it is only about one-quarter, and in a matter of a couple of weeks it would not be detectable. A homely example best illustrates this point, by likening the radium to a milk cow,—milk is secured daily—it sours whether used or not and if one day's milk is lost, we are only temporarily inconvenienced, as with the morrow a new supply is available.

The apparatus is best installed in the duplex type, comprising two working units (one only shown in Fig. II) interconnected and mounted on opposite sides of one frame. Only one unit is operated at a time, with the other held in reserve as an insurance measure against discontinuity of operation and the attendant loss in interest charges against an investment of from $60,000 to $500,000, depending upon the amount of radium in the apparatus.

During the past two years installations of duplex type have been completed in New York City; Buffalo, N. Y.; Chicago, Ill.; Pittsburg, Penna.; San Francisco, Calif.; Fresno, Calif.; and Hartford, Conn.; all of which have shown most gratifying efficiencies ranging over periods of six months to two years, depending upon date of installation.

A complete installation is an assembly of a large number of parts ranging from delicate electrical measuring devices to a robust safe. All installations thus far have proved distinct and separate problems in themselves, requiring a varied and wide experience for their solution.

THE ELECTRICAL ENGINEERING DEPARTMENT IN EXTENSION AND RESEARCH

By Professor C. Francis Harding

Much interesting and valuable work has been done in recent years along research and extension lines by the School of Electrical Engineering at Purdue.

Research: The world war has brought to our attention very forcibly the need for research, and more especially the need for research men. If the University can train a few such men each year, it will be well worth the effort. It is felt that not only is the research work done of value in itself, but the mere fact that it is being done here acts as a great stimulus to students who have some natural inclination for such a line of endeavor. With this idea in view, students of ability have been given an opportunity to contribute to the work which has been done in the Electrical School in the past. A brief description of some of the research problems is given in this article.

Problems Studied: Study of iron wire joints as used in telephone line practice, particular attention being given to tensile strength, electrical resistance, and how these characteristics are modified by the use of welded joints. An investigation of transmission in telephone circuits. This work included tests on a large number of dry batteries.

Fixation of Atmospheric Nitrogen by the Silent Discharge Process: The problem of securing a satisfactory supply of nitrates is an important one and has been the subject of investigation by the Electrical Engineering School for a number of years. The problem is one of finding the conditions which will give the greatest yield for a given power input.

Alternating Current Corona: It is important to determine what takes place when the corona is formed in an alternating current circuit. To study the corona discharge a special camera has been built which makes the exposure sychronously with the change in the alternating current.

Magnetic Leakage in Transformers: Work has been done experimentally which has cleared up some misconceptions regarding magnetic leakage. This investigation has also shown that some of the older ideas of lines of magnetic force are not tenable when more than one magneto motive force is acting.

Trolley Contact Resistance: Trolley contact wheels soon wear out in service, and frequently become very hot. An investigation has been completed in which the loss at the trolley wheel has been determined. The electrical loss was found to be of appreciable magnitude, and to exceed greatly the frictional loss.

Extension: As industry and our social system become more complex, the need for a closer co-operation between industry and the University is being felt. The practical man has a tendency to look down upon college, and in many cases this attitude has been justified. A closer understanding of each other's problems is essential if the University man is to take his proper place in our social system.

The extension work, in the nature of lectures or discussions before bodies of non-technical employees, together with the bulletins of information, should lead to a better appreciation of the non-technical man of the value of a college education.

A summary of extension work carried on by the Electrical School at Purdue follows:

For a period of four weeks, for each of the last two years, a short course has been given for the benefit of the telephone men of the state. This work has been most beneficial to the practical telephone man.

During each year a series of addresses have been given at meetings, and later through correspondence the problems of the telephone man have been discussed and in many cases a solution secured.

A circular of the Experiment Station has been issued dealing with the methods of preserving poles against decay. This circular puts in the hands of the telephone and telegraph operator an unbiased report concerning the merits of the different methods of treatment.

In the High Voltage Laboratory numerous tests have been made both for manufacturers and users of high-voltage insulators. Tests have been made on glass insulators ranging in size from the telephone insulator up to those used by the Montana Power Co. at 70,000 volts. Other tests on porcelain insulators have been made under both the dry and rain conditions. Puncture tests under oil have also been made in many cases.

For the information of the Joint Purchasing Committee of the State of Indiana, a series of photometric tests on 25-watt tungsten lamps has been made. From these tests and from the life tests now being made on the same lamps, it is possible to determine the best lamp, from the standpoint both of efficiency as a light producer and of long life.

A large number of tests have been made on different types of storage batteries, both for the manufacturer and the user. One of the tests made recently was to determine the characteristics, possibilities and limitations of the so-called dry storage battery. This test was of great value to the makers of this battery, as they were able to secure reliable information concerning their product.

A bulletin, under the auspices of the Engineering Experiment Station dealing with the operation and costs of small electrically driven pumps, has been issued. This publication is especially valuable to the small municipality which is interested in the pumping of water for both fire protection and domestic use.

Additional information is now being prepared upon small pumping outfits for domestic use. Publications of this kind written without the use of technical terms are of great benefit to the user of these appliances who, as a rule, has no special knowledge of electricity or its applications.

For the benefit of the rural communities a study is being made of the most successful practice for the transmission of small amounts of power. In order that such lines shall be a success they must be built in a satisfactory manner, and yet the cost of service must be low enough so that the consumer can use the power profitably. To be attractive from the central station standpoint the lines must pay a reasonable return on the investment. The results of this investigation will be of great benefit to small communities contemplating or now using electric power.

Even closer contact with industrial problems is being secured this year than ever before. A series of discussions by Professors Harding, Ewing and Rowell, is being conducted before different groups of the National Association of Stationary Engineers. The subjects dealt with are those which will give these engineers some knowledge of the fundamentals of electricity and its applications to measuring instruments, motors, and generators.

THE INSPECTION TRIP TO DAYTON AND VICINITY

By MERRITT B. MILLER, E. E. '21

On Wednesday, May 12, 1920, all the engineers of Purdue, with the exception of the Civils, left LaFayette on a special train on the Big Four for Dayton, Ohio, where we arrived Thursday morning. After breakfast everybody met at the Engineers' Club, where we boarded cars and trucks which were to take us to the Miller's Ford Power Plant, just outside of Dayton.

This power plant, which was put into operation March 22, 1918, is a model steam power plant in every respect of the word. It is so located that transportation facilities are available and cooling water from the Miami River may be obtained. The present generating capacity is 25,000 kw., 6,600 volts, 3 phase, 60 cycles, but the ultimate capacity will be 100,000 kw. Coal storage for 60,000 tons is provided.

The boiler room is laid out for two rows of three boilers each, with the firing room perpendicular to the generating room. At present four 1,373 H. P. B. & W. boilers are installed with 14 Taylor stokers fed by gravity from a brick-lined steel coal bunker having a capacity of 975 tons. Forced draft is used under the grates. The boilers are equipped with soot blowers, cinder catchers, and feed water regulators. The boilers are operated at 225 lbs. gauge and 125°F. superheat. Each boiler is equipped with two Bailey boiler meters, which record the steam flow, air flow, steam temperature, flue gas temperature, and draft, and with CO_2 recorders.

Located in the basement is apparatus for making complete water rate tests on any or all of the boilers, and also apparatus for sampling and testing coal. A 3,000-gallon water softener is located in the boiler room.

The main steam header is laid out on the ring type with remote controlled sectionalizing valves, and is insulated with 3½" of 85% magnesia pipe covering.

The turbine room equipment consists of two 12,500 kw., 3 phase, 6,600-volt 60-cycle generators, direct connected to nine stage G. E. Curtis turbines with 170 kw exciters, 250 volts, 1,800 r. p. m. Each generator requires 85 kw. for excitation at full load; thus each exciter is capable of furnishing excitation to both generators. A 100 kw., 2,500-volt, 900-r. p. m. turbine driven exciter is also available. A 75-ton travelling crane is provided for making repairs, etc.

In the basement are two 15,000-square foot condensers with the necessary pumps. An air compressor is provided for driving tube cleaners, etc., and there is an oil filter for purifying the lubricating oils.

Each generator takes its cooling air through an air washer which insures clean dry air and prevents accumulations of dirt and foreign matter collecting on the coils and parts of the machines.

A most modern and complete switchboard of Westinghouse make is provided. All switches and other apparatus are remote controlled, so that the operator has complete control of the entire plant at all times. A 33,000-Volt outdoor substation is located near the plant and under control of the switchboard operator. It has a capacity of 18,000 kva. It consists of three banks of 3 each 2,000 kva. 6,800-33,000 volt water cooled transformers.

After visiting this plant the group was conducted to the factory of the National Cash Register Company. Here the entire process of making cash registers of all kinds was seen. The process of applying the final finish was of particular interest. A copper plate is made from a photograph of the wood desired for the finish and an impression made from this plate on a rubber roller, which transfers the finish to the surface of the cash register.

An entertainment by the youngest orchestra in the world was given after the boys had been through the plant. Then a very welcome and satisfying dinner was served.

From the N. C. R. the engineers were conducted to the Dayton Engineering Laboratories and the Delco Light Company, where all sorts of automobile starting and ignition apparatus were seen in the process of manufacture.

Probably the most interesting part of this visit was the showing made of the methods of working and the methods of time keeping used in the works. Time studies are made of each process and the best and quickest ways of doing each job determined.

Friday morning the train, also used as a hotel during the stops, left for Middletown, where the process of making high-grade sheet iron was seen in the works of the American Rolling Mills. The open hearth furnaces and the treatment of the iron during the process of rolling was very interesting. The American Rolling Mills maintain a very elaborate laboratory for testing and maintaining their quality of product up to standard and for widening the field of application of Armco iron goods.

A good dinner which was waiting at the restaurant of the office employees received full justice from the tired and hungry boys. After the dinner an entertainment was offered by the women employees and greatly appreciated by the entire audience. Several talks by officials of the company were then given, after which our train took us to Hamilton.

At the plant of Hooven, Owens, Rentschler Company a great many surprises were in store for the unexperienced members of the party. Machines were there in process of construction the size of which had never been imagined by most of the visitors. Huge engines and sugar mill equipment were being erected and manufactured. The methods of handling some of these large machines was unique, to say the least. In the machining of some of the parts, the cutting machine itself rotated instead of the piece.

The new Ford tractor plant was of interest to many, as it demonstrated the latest process of quantity production of machines. The power for operating this factory is derived from low head water turbines operating electric generators. The plant was only under construction at the time of the visit.

At the plant of Niles, Belmont, Pond Company many very large and interesting tools were seen in the process of manufacture. The foundry where the large castings are made was of particular interest.

That evening, Friday, the Chamber of Commerce of Hamilton provided a banquet at which Colonel Beauchant proved a very able and entertaining toastmaster. Talks were given by men of Hamilton, faculty members, and students.

Saturday morning we visited McCook Aviation Field and saw the planes used in modern warfare for attaining very high altitudes. A conservator for compressing air and feeding it to the engines at extremely high altitudes proved of general interest. Films and talks by army officers were on the program.

In the afternoon interurban cars took us all out to the place where one of the huge dams is being built for the Miami Valley Conservancy. One of these dams—there are five of them in all—is 4,700 feet long and 1,100 feet thick at the base, tapering off to 300 feet at the top. It is designed to hold back all the water at flood time except that which can safely be taken care of by the drainage systems of Dayton and vicinity. Two concrete tubes are provided for letting the water through the dam.

The method of construction of this dam is unique, in that it is made of gravel deposited by the hydraulic process. The gravel is hauled to the highest point on the dam by cars and washed down in pipes to the place where it is to be deposited. The flow of water from the point of discharge of the pipes is toward the middle of the dam and the finer particles and silt are deposited in the center, which makes the dam proof against corrosion and also against penetration of the water.

Saturday evening the Chamber of Commerce of Dayton entertained at a banquet. Several new "stunts" were provided, and some talks given by prominent men of Dayton. The talk of Mr. C. F. Kettering, of the General Motors Corporation, will long be remembered on account of the food for thought that he pointed out in the modern methods of education.

It was a very tired crowd of boys and professors who were on the train that left for LaFayette that night, but every one brought back the impression that the engineering profession is a great and important profession, and that Dayton and vicinity is fully awake to the requirements and the needs of that profession.

PURDUE SENIOR ENGINEERS' INSPECTION TRIP

By E. R. Moore, E. E. '21.

During the first semester of their Senior year all engineering students at Purdue University are required to make a three or four day inspection trip to some nearby cities for the purpose of studying manufacturing and operating methods as they are carried out in practice along engineering lines. This year the Chemical, Electrical, and Mechanical Engineering students made the trip at the same time, starting Tuesday, Oct. 5th, and lasting until Saturday, Oct. 9th. Visits were made to Milwaukee, Chicago, Gary, and nearby towns.

Early Tuesday morning the Seniors wended their way to the Monon depot, where a special train was provided to transport them to Chicago. At Hammond the Electricals and Mechanicals transferred to electric cars for a twelve mile ride to Gary, Indiana. Arrival was made at Gary about 11:30 a. m. and an immediate search was made for the various restaurants, cafes, etc. The excellent cafeteria at the Y. M. C. A. received the brunt of the forage and soon everyone was ready for the first inspection to begin. At 12:30 assembly was made at the entrance of the Indiana Steel Company. Many cameras were in evidence throughout the party, but to our sad dismay we found that, according to the gate watchman, "orders is orders," so all cameras were checked at the gate. The party was then divided into several groups and the next three hours were spent in "intensified walking and gawking." The principal processes in the manufacture of steel and iron products were traced, from the unloading of the coal and ore to the final forming of the finished product. The first feature to interest us was the giant electrically operated boat-unloaders, the huge bucket jaws of which are capable of taking a 15-foot bite of ore from the holds of the ore-freighters and transporting this load of over 12 tons to the ore piles on shore. The next point of interest was the blast furnaces and we were fortunate enough to witness the tapping of one of these. Other items of interest at the steel mills were the Bessemer furnaces, the rolling mills, the car-wheel plant, and the power plant. Electric power for the entire steel plant is furnished by six alternators each driven by two 5,000 horsepower gas engines which burn by-product gas from the blast furnaces. The inspection of the steel mills was completed about 4:00 p. m., so we took special cars to Hammond, transferred to the Monon again, and soon arrived at Chicago, where we were assigned rooms at the Atlantic and Stratford Hotels.

The Chemical Engineering class had remained on the special train and came direct to Chicago, where they registered at the Hotel Atlantic about noon. They spent the afternoon at the National Lead Company, where the Dutch-lead process of paint manufacture was inspected. The process was followed from the treating of the lead metal with acetic acid to the formation of the finished paint. Another interesting process at this plant was the cold-drawing of the lead by hydraulic pressure into various forms such as wire-solder, fuse wire, etc.

Wednesday the students of each department visited different concerns, each class visiting certain concerns which were more directly connected with their respective branches of engineering. In the morning the Electricals visited the Standard Steel Castings Company in South Chicago, where a large three-phase electric furnace was observed in operation. The afternoon was spent at the Wabash exchange of the Chicago Telephone Company and at the Automatic Electric Company. At both of these places the party was broken up into small groups, about ten men to a group, and each group was furnished with a guide. At the exchange the methods of interconnection, call-recording, telephone testing, etc., were observed and the operating features were explained to us, while at the Automatic Electric Co., the manufacture and operation of automatic phones and exchanges were studied. The Chemicals spent the morning at the Universal Portland Cement plant at Buffington, Ind., where the making of cement was traced from the raw products of limestone, shale, blast furnace by-products, etc., to the final sacking of the cement. The students were especially interested in the Cottrell dust precipitators which make use of high voltage in precipitating the cement dust. The afternoon was spent at Whiting, where the Standard Oil Co.'s plant was inspected. One point of interest here was the sulphuric acid concentrators where the impurities are boiled from the crude oil. While inspecting these it was agreed by all that a glass screen to completely cover the head and face should be the greatest requisite. Overcoats would also have been much in order while inspecting the huge refrigerators where the paraffine for the manufacture of "Para-wax" is separated from the oil by solidifying it out. This inspection was completed late in the afternoon and the party took the train back to Chicago. The Mechanicals spent the morning at the McCormick works of the International Harvester Co., and the afternoon at the Hawthorne plant of the Western Electric Co. They were served lunch at the restaurant of the latter concern and were then divided into small groups for inspection. Practically all the departments in the plant were visited and the manufacture of telephone apparatus was observed in all its stages. The making of underground and submarine cable was especially interesting and it was watched from the winding of the first insulation on one strand to the forming of the entire cable and the application of the lead sheath by the drawing of the cable through a warm lead bath under heavy pressure. Another point of interest was the large power plant with its modern boiler-room equipment.

On Thursday the Mechanicals and the Electricals took special cars on the North Shore electric line, the Mechanicals stopping off at Kenosha to visit the Nash Motor Company, while the Electricals went on to Milwaukee and visited the Cutler-Hammer Manufacturing Company. The Cutler-Hammer Co. manufacture all sorts of electrical control apparatus, crane magnets, magnetic clutches, Thomas electric gas meters, etc. The many special machines for making intricate control parts were of great interest. We were also interested in the manufacture of "Thermoplax" and "Pyroplax," which are forms of heat resisting insulation compounds that are molded into any desired shape by compression under extremely high pressure. At about 1:00 p. m. the Mechanicals and Electricals met again at the Allis-Chalmers Co. and they were served lunch in the company's restaurant. The afternoon was then spent in the inspection of large turbine and alternator manufacture. One feature of interest was the casting and forging of the very large parts.

The Chemicals visited the steel mills in South Chicago during the morning and it was here they learned that the gentle art of "penny-pitching" is **absolutely** prohibited in that neighborhood (for particulars see Professor Peffer). The By-Products Coke Corporation plant in South Hammond was visited during the afternoon. The Semet-Solvey coke process was observed in operation here. Ammonia and other coal tar products are manufactured and most of the coke is sold to the steel mills, while the city uses the gas that is produced.

On Friday the Mechanicals visited Sears-Roebuck Co., the Union Stock Yards, and the Swift Packing Company. The Chemicals visited the Underwriters' Laboratories in Chicago and the Corn Products Company's refinery at Argo, Illinois. At the Underwriters' Laboratories they found that everything was being tested from steel safes down to sprinkling systems and electric fuses. Spectacular heat tests were witnessed as they were being run on various building materials such as glass, roofing, columns under compression, etc. The entire Underwriters' Laboratory building is made as nearly fire proof as possible. Chairs, desks, and so forth are all made of metal. Now, ladies and gentlemen, hold your noses, for we have left Chicago and are nearing Argo. Of all the odors that were ever odored this was the worst in our experience. The gentle perfume of fermented corn and sulphur fumes, glucose, etc., were all in evidence. The features of most interest were the large vats where the corn is soaked in a weak solution of sulphurous acid, and the automatic can-filling machinery. Another point of interest to some was the four 200-foot stacks supported only by girders on top of the building. The Electricals spent the morning inspecting a portion of the Aurora, Elgin & Chicago electric railway, including the power station at Batavia and the automatic substation at Warrenville. The Western Electric Company was visited during the afternoon, the same inspections being made that the Mechanicals had made two days before.

On Saturday morning all of the parties inspected the Fish street plant and the Quarry street station of the Commonwealth Edison Co., where they observed a modern central power station in operation. In the afternoon everyone went out to Stagg Field to see the football game between Chicago and Purdue, so Purdue was not at all short in ardent rooters. A special train late that evening brought us all back to LaFayette and our sightseeing vacation was at an end. However, although we called it a "vacation," it was really an education in itself, for we all returned with a much broader view on some of the immense problems and methods of manufacture and industry. We feel exceedingly grateful to the many factory and company officials for the courtesy and welcome shown us and we hope that the relations between the industries and the universities will always remain so sincere.

CONCRETE CONSISTENCY

By J. B. NOTHHELFER and C. G. HEINMILLER, C. E. '21.

Flowability is one of the several expressions used to describe the consistency or placeability of concrete. The quality of a concrete or mortar mixture which has to do with ease of placing may be referred to as consistency, flowability, mobility, workability, and these words, although having perhaps slightly different meanings to many people, are generally synonymous as used.

The consistency which must be used in any case depends upon the nature of the work, type and arrangement of forms and reinforcing steel. For any given condition there is some minimum consistency which must be attained to result in good workmanship, economy, and proper progress in the process of consistency. With a certain set of conditions, consistency may be increased by the use of more mixing water, which in turn lowers the compressive strength. It is generally agreed that concretes must have the same consistency to be comparable, yet we have not agreed upon a satisfactory method of measuring and controlling consistency. Consistency has usually been crudely estimated by the "eye," "judgment," or "feel" of the operator. This method of measurement gives widely varying results.

One of the important factors of consistency is the water content. In concrete water serves three important purposes:

1. Water reacts with the cement to form a binding material which unites otherwise non-cohering sand and stone. If not enough water is used, the chemical action will be incomplete; if too much water is used, the binder will be too dilute.

Undue dilution of concrete is readily possible, but it is accomplished by impairment of strength, just as glue may be a valuable adhesive when of proper consistency, while the same glue, if too dilute, may be useless for like purposes although later evaporation may gradually restore its cementation value.

2. Water operates to flux both dissolved and undissolved cementing substances over the surfaces of sand grains and stone particles, rendering possible extensive and close adhesion by carrying these substances to all the irregularities of the particle.

3. Water acts as a lubricant and allows the concrete to flow into position. Too much is generally used

for this purpose. The proper consistency can be brought about by a cleaner and more thorough mixing.

The more we learn about concrete, the more certain it is that too much water is injurious to it. The only safe rule is to use first enough water to produce a concrete that is workable on the particular job, and to mix it for a long enough time. The exact amount of water cannot be stated because—

1. The materials may be wet.
2. Fine materials require more water.
3. Coarse materials require less water.
4. A rich mixture requires a relatively less amount of water to produce a workable concrete.

It is, therefore, important for the concrete worker to learn the proper appearance of good concrete, which is of such a consistency that it is workable on the job and to watch the mixing operation with a view to time and the correction of materials and water. Good concrete never has isolated batches of stone or mortar, and is always uniform in texture and color.

Tests show the following effect upon the strength of concrete of various percentages of water, based on weight of aggregate.

From "Concrete Work" by Hatt and Voss, Vol. I.

Consistency	% of water	Comp. strength in Pounds per sq. in.
Very dry	5.4	2,500
Dry well rammed	5.4	4,200
Medium	6.0	5,200
Wet	9.2	4,800
Very wet	11.0	3,500

A measure of consistency was devised by Prof. Duff A. Abrams, of the Structural Materials Laboratory, Lewis Institute. This method of measuring consistency is done by measuring the sag or shortening of a concrete cylinder. It is called the cylinder slump test. There is a modification of this called the cone slump test. While both of these tests are far superior to the old method of "eye" and "feel," they fail to meet fully the requirement of such a test. The test is performed as follows:

Mix the concrete thoroughly, adding the estimated amount of water. Tamp the concrete into a galvanized iron mold which is a cylinder 6 inches in diameter and 12 inches high. The cylinder is filled in two layers. Each layer is tamped for forty strokes with a ⅝-inch round steel rod 18 inches long.

Then draw the mold up off the specimen and note how much the specimen shortens or sags in height.

A relative consistency of 1.00 (normal consistency) requires the use of such a quantity of mixing water as will cause a slump of ½ to 1 inch in a freshly molded 6 by 12 inch cylinder of about 1:4 mix upon withdrawing the form by a steady upward pull. This consistency is somewhat dry for most concrete work, but can be used where light tamping is practicable.

A relative consistency of 1.10 (10% more water than required for normal consistency) is about the dryest concrete which can be satisfactorily used in concrete road construction. This consistency will give a slump of about 5 to 6 inches.

The slump test is not a very satisfactory method of measuring consistency.

Another method of measuring the consistency of concrete was recently devised in the concrete laboratory of the U. S. Bureau of Standards, Washington, D. C. This method appears to be very good. The consistency is measured by an apparatus called the "flow table."

The flow table consists of a metal covered table top which can be raised vertically by means of a cam working at the end of a vertical post to which the top is attached. The height of the drop can be adjusted by means of a bolt at the lower end of the shaft. A mass of concrete or mortar is molded at the center of the table in a sheet metal mold, which has the shape of a hollow frustum of a cone. For aggregate up to 2 inches minimum size the cone has a height of 6 inches and upper and lower diameters of 8 inches and 12 inches. For smaller aggregates, when made up in small quantities, a cone having height of 3 inches and upper and lower diameters of 4 inches by 6 inches is used. The mass of concrete is tamped sufficiently to completely fill the form. The form is withdrawn and the table dropped 15 times through a distance of ½ inch. The mass flattens and usually spreads concentrically. Two diameters at right angles to each other are measured, the long and short diameter if the difference is apparent, by means of a self-reading caliper which is so graduated that the sum of the two readings is the value of consistency, which may also be calculated by dividing the new diameter by the old and multiplying by 100.

Comparisons have been made by the U. S. Bureau of Standards between the cone slump and the flow table. A large number of tests were made and averaged.

The cone slump in inches and the flow table number for a 1-2-3 gravel concrete is thus related: Flow table numbers 140, 150, 160, 170, 180, 190 correspond to inches of slump ½, 1¼, 1¾, 2¼, 2¾, 3½, respectively.

The flow table shows a uniform change in flow numbers as the amount of water increases. The cone slump, however, shows a sudden increase in slump when the concrete becomes rather wet.

The slump is more erratic than the flow table.

In tests that have just been completed using a 1-1½-3 gravel concrete show a relation between cone slump and flow table as follows:

Flow number 140, 150, 160, 170, 180 correspond to inches of slump ½, 1, 1¾, 2¼, 3.

DETERMINATION OF TRACTOR ROLLING LOSSES

By M. K. Edmunds, M. E. '21.

As the internal combustion engine was developed, its use was gradually extended until it found its way into all fields of human activity.

One of these fields, and in many respects the most important, is the basic industry of agriculture. With the disappearance of frontiers and the ever-increasing urban population, the problem of more intensive farming to meet the growing demand for foodstuffs became the paramount social and economic question. A more intensive cultivation of fertile regions and the necessity of utilization of less productive soil required better farming methods and equipment, and, above all, a more economical and unfailing power to supplement the inadequate and expensive animal power. As a result, the tractor and tractor industry came into existence.

At present there are at least one hundred and fifty makes of tractors, some produced by long-established and well-known manufacturers. An investigation of the various designs, methods of rating and performance records shows such diversity of ideas, claims and results as to indicate the lack of definite information upon which to base the design of tractors.

The results of recent tests of a number of tractors show, in one case, that only 33 per cent. of the power delivered by the engine at the pulley appeared at the drawbar. Another tractor under the same conditions delivered 82 per cent. of its power at the pulley to the drawbar, showing in the case of the former an additional loss of approximately 50 per cent. of the power in transmission and rolling.

The physical conditions under which the tractor operates greatly affect the power output for the quantity of fuel used. It is evident that a tractor plowing tough, sticky clay, soft meadow land, or loose sandy soil will give different results at the drawbar, not only because of the difference in the tractive effort, but in a large measure because of the varied rolling loss. This loss cannot be entirely eliminated, but if it can be accurately measured a way will be opened for such changes in design as will materially decrease it.

At present, according to the information at hand, there is no equipment available for measuring the rolling loss directly in the field.

As a graduating thesis, under the direction of Prof. G. C. King, of the School of Mechanical Engineering, the writer is designing "A Tractor Attachment for Field Testing," or, rather, a set of dynamometers by means of which an exact measurement of the power delivered to the tractor at the periphery of the drivers and the power output at the drawbar can be made. From the relation of these two, the distance traveled and the revolutions per minute of the drivers, the rolling and the slippage losses will be determined.

The attachment will consist of four parts: a dynamometer for measuring the power input at the periphery of the drivers; another for measuring drawbar pull; an apparatus for measuring the distance traveled and the revolutions of the drivers, and a recording device.

The power input at the drivers will be determined from the amount of lift of the front end of the tractor, resulting from the pull on the drawbar, which acts as a prony brake and can be reduced to the equation

$$\text{B. H. P.} = \frac{2\pi RNW}{33{,}000}$$

As an illustration, let us assume the following conditions: horizontal distance between front and rear axles, 8 feet; diameter of drivers, 56 inches or 4.67 feet; speed of the drivers, 15 r. p. m.; distance traveled per hour, 11,220 feet; drawbar pull, 1,500 pounds; place of hitching, 1 foot below the horizontal plane of the rear axle; the amount of front end lift, 350 pounds.

The power developed by the tractor at the periphery of the drivers:

$$\text{T. H. P.} = \frac{2\pi \times 8 \times 15 \times 350}{33{,}000} + \frac{2\pi \times 1 \times 15 \times 1500}{33{,}000} = 12.28 \qquad (1)$$

Theoretical drawbar horse power computed on the basis of the revolutions per minute of the drivers, disregarding the slippage:

$$(2)\ \text{T. D. B. H. P.} = \frac{4.67 \times \pi \times 15 \times 1500}{33{,}000} = 10$$

Actual drawbar horse power computed on the basis of the distance traveled:

$$(3)\ \text{A. D. B. H. P.} = \frac{11220 \times 1500}{33000 \times 60} = 8.5$$

Power loss due to rolling and slippage $=12.28-8.5=3.78$ H. P. or $\frac{3.78}{12.28}=30.81$ per cent.

Power loss due to rolling $=12.28-10=2.28$ H. P. or $\frac{2.28}{12.28}=18.58$ per cent.

Power loss due to slippage $=10-8.5=1.5$ H. P. or $\frac{1.5}{12.28}=12.23$ per cent.

In the design of these dynamometers cognizance has been taken of the difference in size, design and weight of the tractors in use, also the range of the possible drawbar efforts. As the successful operation of these dynamometers depends on the maintenance of certain pressures, provision has been made to maintain these by varying the sizes of the working parts. Care has also been taken to assure sufficient ruggedness of the attachment to withstand the hard use under which the tractors as a rule operate.

The addition of this attachment to Purdue University's present equipment for testing tractors will enable her to supplement the work done under laboratory conditions with tests performed under the actual conditions of field service, and thus render the tractor industry invaluable service by furnishing definite information on the subject of rolling losses.

WHAT'S WHAT AT A SOPHOMORE CIVIL CAMP

By H. H. Bloemker, C. E. '22,

Everyone knows that just about the time the rest of the student body is preparing to make a rush for the summer cottage or a grab for the shining silver slivers, the Sophomore Civil Engineers are hooking a train or a ferry for the lakes, woods, swamps, and dunes of Michigan. Everyone knows that when we reconvene in the fall those same Civils make their appearance with a heavy coat of tan and a suit full of nice empty pockets. But what do they do there? To what manner of place do they go? How do they live? What is the practical value of the work?

The camp is located on the shores of Glen Lake, Michigan, on the Grand Traverse peninsula. The site is far from any railroad, far from any town of reasonable size, and not easy of access. However, the natural conditions for the work to be done are exceptional. The terrain is a conglomeration of steep wooded hills, bald glaring sand dunes, impenetrable swamps and beautiful lakes. Every condition which might confront the surveyor in actual work may be found.

And actual work is the object of the camp. Problems taken up during the last camp consisted of complete plans for a highway through the forests and hills of Leelanau county, charting Glen Lake, establishing a triangulation system over the entire country surrounding the camp, topographic mapping of a large portion of this area, and determination of true north and time, by polar and solar observation. This work was supplemented by a certain amount of office practice and drafting work.

In the planning of the highway, the work included a reconnaissance survey by each party of six, thirteen of which made up the working force of the camp, and the running of a preliminary transit line and level circuit over the route decided upon. This data was then mapped and the final location laid out on paper. This line was then staked out in the field. The next step was the making of complete topographic mapping of the area including the final and original lines. This served as a prospectus for the entire work. A final line of levels over the actual course was taken, slope stakes for the purpose of locating the dimensions of cut and fill were set, and the actual amount of excavation and embankment was computed. The work was identical with that which would be gone through in actual practice, each party acting as a separate unit with a highway of its own.

In making surveys of large areas it is necessary to establish a few points with great precision in order to insure the accuracy of the system as a whole. Such a system was thrown out over the country surrounding the camp. Eight permanent points of vantage were made to serve as triangulation stations, and the definite angular relation of each to the other was determined. The actual distance between two of these stations was then measured in accordance with the most precise method, an invar steel tape supported above the ground on stakes and subjected to a constant pull being used. Computations of the actual distance included correction for temperature variation, for sag, for slope of land, for tension, and for reduction to sea level. From this precisely determined base line the actual distance from each point in the system to each other point was computed. The region was then mapped with this system as a base.

Complete soundings of the lake were made from boats which were accurately located by means of transits stationed on the shore. These points were then plotted, making a chart of the lake.

Observations on the sun were made with both the transit and the sextant, and on polaris with the transit. These observations were taken for data in computing the local mean time, mean sidereal time and true north. A course in descriptive astronomy was administered by Dr. W. K. Hatt.

The instructional staff consisted of Dr. W. K. Hatt, who was personally in charge of the camp; Prof. W. A. Knapp, Prof. G. E. Lommel, Prof. C. C. Cunningham, and Mr. J. H. Parmer. Mr. W. F. Riehle acted as curator. The entire faculty body lived in very close touch with the student body, and a very congenial camp resulted.

Recreation was plentiful. The camp boasted a good baseball team, an exceptional orchestra, some fast tennis players, swimmers, and fishermen. Hiking, the horseshoe game and dancing were also enjoyed.

All in all, the Civil camp is a great success. It gives the student the practical experience which he could not obtain at the University, but which is necessary in getting the usual position. It unites the students in themselves and with the instructional staff. It takes up a wide range of work. It is conducive to good health and clean living. A summer spent at camp is indeed a paying proposition for the student in Civil Engineering.

The Purdue Engineering Review

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PURDUE BRANCH OF AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The first departmental society in the School of Electrical Engineering originated a little more than twenty-four years ago when the "Electrical Society of Purdue University" drew up a constitution on February 5, 1897. Suffrage was limited to juniors and seniors, but the other under-graduates were permitted to hold associate membership. This society continued under the above name for six years and then, by the efforts of Prof. W. E. Goldsborough, head of the Electrical School at that time, was transformed into the far more stable form of "Purdue Branch of American Institute of Electrical Engineers." A few months later a subdivision was founded which had separate officers and meetings and which was termed the "Telephone Section" of the Branch. This form did not prove to be so efficient as might have been expected and which resulted in the combination of the two organizations. On April 9, 1918, a revision of the constitution and by-laws was made which has remained intact since that date. At present there are 130 members of the local branch and 109 student members of the National Institute.

The object of the branch is to advance and disseminate electrical knowledge among its members and to afford a means of independent activity for the students.

Meetings are held every other week, at which time outside speakers are arranged for and movies are shown whenever possible.

The meetings held this year are as follows:

Sept. 25, 1920—"Membership of A. I. E. E.," by Prof. A. N. Topping and Prof. D. D. Ewing.
"Engineering Societies," by Dean Potter.
"Field of Electric Railways," by Prof. C. F. Harding.

Oct. 19, 1920—"Sound Ranging," by Prof. L. D. Rowell.
Nov. 9, 1920—"Transformers," by Mr. E. A. Wagner, of G. E. Co.
Nov. 23, 1920—"Transformer Costs," by Mr. J. G. Bailey.
Dec. 14, 1920—"Hydraulic Turbines," by Mr. D. J. McCormack.
Jan. 11, 1921—"Queen of the Waves," movie film.
Feb. 1, 1921—"High Voltage Demonstration," by Mr. K. B. McEachron.

The most successful meeting, however, was a combined gathering with the Indianapolis-Lafayette Section held in the form of a banquet at Fowler Hotel. The main speaker of the evening was A. W. Berresford, president of the National Institute, his subject being, "The Professional Man and the Operation of American Institute of Electrical Engineers."

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PURDUE STUDENT SECTION AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The national organization of the American Society of Mechanical Engineers recognized the requests of student societies, and in 1907 authorized the formation of student branches. In 1908 such branches were formed at Stevens Institute of Technology and Cornell University. Purdue was the third university to request a branch, and was one of thirteen to be organized in 1909. At present there are forty-nine student branches. The national society requires that each student branch elect a member of the faculty as honorary chairman. Each branch is governed independently by its own constitution and by-laws, subject to certain limitations.

This year has been marked by a growth in membership of the local branch, and the semi-monthly meetings have been very interesting. The following is an outline of the addresses which have been delivered at these meetings during the first semester:

At the first get-together meeting of the year, Dean Potter spoke on the activities of the A. S. M. E. and urged that the attendance be kept up. Professor Young spoke on "The Man Who Puts Off a Task Until Tomorrow." The next meeting was of a more technical nature, Professor Ludy choosing as his topic "The Value and Use of Condensers in Steam Power Plants," illustrating his address with slides of condensers and vacuum pumps. At this meeting, also, Dr. Moran gave a short talk on the Purdue Union. Dean Potter brought up many interesting points in his discussion of "The Engineer and Business Correspondence" at the following meeting.

The first practicing engineer to give an address was Mr. A. R. Martin, '08, of the Allis-Chalmers Co., who spoke on the recent developments of hydraulic turbines. He had models of several types of turbine runners and also showed slides giving the latest developments in turbine draft tubes. After the next meeting, at which Professor Young spoke on "The Conservation of Power and Resources of the Country," came the last two meetings of the semester, at which addresses were given by practicing enginers, Mr. J. B. Wise, engineer of the Cleveland-Osborn Manufacturing Co., and Mr. Louis Ruthenberg, of the Dayton Engineering Laboratories Co. Mr. Wise spoke on "Foundry Practice in Making Machinery," bringing out the advantages of molding machines and the types of patterns used in them. Mr. Ruthenberg gave an idea of the broad outlook an engineer should have. In his address on "The Business of Engineering," he brought out the fact that an engineer must use traditions, formulas, and rules to accomplish his purpose, and not be held back by them.

THE CHEMICAL ENGINEERING SOCIETY

The nucleus out of which the Chemical Engineering Society at Purdue has grown had its beginning in 1911. In 1913 a constitution was adopted in which the organization was given the name of The Chemical Engineering Society of Purdue University. At that time about forty-five members were enrolled on its books, while at the present time it can boast of a membership up in the two-hundreds. The chief object of the society is to cultivate an interest in, and a knowledge of, the current work in chemistry and chemical engineering.

The first meeting of the current year was held November 5, 1920, in the Y. M. C. A. Hut, a very informal gathering where every one had splendid opportunities to become acquainted. Interesting talks were given by members of the faculty, Prof. H. C. Peffer closing the program with a few words which he purposely made short in order that the cider, doughnuts, pie, and apples might be properly taken care of.

The society has been instrumental in engaging the services of several highly trained men to speak at Purdue. On November 11, 1920, at an open meeting members of the University took advantage of the opportunity of hearing Mr. S. R. Rectamus, '09, deliver an illustrated lecture on Armco iron. Mr. Rectamus, in his present position at the American Rolling Mills Co., at Middletown, Ohio, has had a share in the development of Armco iron, one of the most important of the late advances in the metallurgy of iron.

Mr. R. D. Oilar, another Purdue graduate of the '09 class, an authority on vegetable oils, gave an interesting talk before the society December 15, 1920, on "New Vegetable Oil Refineries." Mr. Oilar has charge of the oil equipment division of the Brecht Company, the largest manufacturers of packing house machinery in the United States, developing, promoting, and selling machinery for the manufacture of vegetable oils.

February 8, 1921, under the auspices of the society and Phi Lambda Upsilon, Brigadier-General Amos A. Fries, head of the U. S. Chemical Warfare Service, visited the Campus. His lectures on "Engineering in Chemical Warfare" drew capacity crowds. When he was made chief of the American Chemical Warfare Service in France in August, 1918, he was faced by tremendous odds, as the American army had little knowledge of gas warfare. To build up a personnel of chemically trained officers was a difficult task in itself, but his accomplishments take on an aspect of the miraculous when it is noted that at the signing of the armistice his command consisted of more than six hundred officers and three thousand men.

The society considers itself very fortunate in being able to bring such men as these to our University.

CO-OPERATION BETWEEN THE SCHOOL OF CIVIL ENGINEERING AND THE STATE OF INDIANA

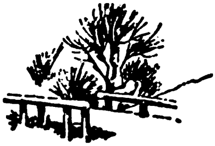
The School of Civil Engineering has direct contact with the affairs of the State of Indiana through the official Road School for County Road Superintendents, and through the Laboratory for Testing Materials, which is the official testing laboratory of the Indiana Highway Commission, and through the appointment of Professor W. K. Hatt as State Engineer for the Department of Conservation. The legislature last winter created the Division of Engineering in the State Conservation Commission, the main work of which is in the control of the waters of the State in respect to their levels and their purity, canals and water power. General engineering services for other State boards will be rendered and the topographic survey of the State.

PURDUE STUDENT BRANCH AMERICAN SOCIETY OF CIVIL ENGINEERS

D. A. Leach, '21, President
L. Earl, '23, Secretary
N. E. Manville, '22, Treasurer

The Purdue Student Branch of the American Society of Civil Engineers was established in March, 1921. The former Purdue Society of Civil Engineers, merged into this organization, was established in 1895. For a term of years it published a yearly volume of transactions called "The Purdue Civil Engineer," later merged into the Purdue Engineering Review.

The American Society of Civil Engineers has been distinguished for its high ideals and high professional standards. Eighty per cent of its membership graduated from colleges.



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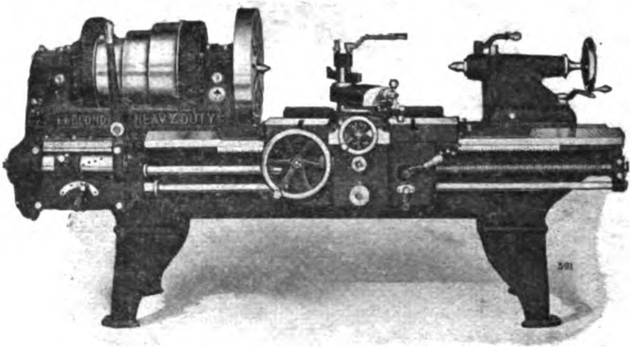

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